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THE AUSTRALIAN AND NEW ZEALAND SPECIES OF *PITTOSPORUM**

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Many of the Australian and New Zealand species of *Pittosporum* have long been treasured in gardens of Australia, New Zealand, France, and England, for their flowers, foliage and sweet scent, and several are common hedge plants and ornamentals in California and Florida. In addition to an aesthetic appeal, the species have scientific interest and potential economic value.

The most recent inclusive treatment of *Pittosporum* is in the treatment of the family Pittosporaceae by Pritzel,¹ who found it was impossible to make a satisfactory arrangement or classification of the genus and relied upon the geographic distribution of the species. He wrote as follows:

Etwa 160 Arten in den Tropen und Subtropen der östlichen Hemisphäre von West-Afrika bis zu den Inseln des Pazifik. Da eine befriedigende natürliche Gliederung der Gattung noch nicht gegeben werden kann, so bleibt nichts anderes übrig, als sie nach ihrer Verbreitung zu behandeln. Ein künftiges System der Gattung wird sich vor allem auf die Frucht zu gründen haben, und diese ist bei vielen Arten noch nicht genügend bekannt.

He discussed and keyed the species separately of the following regions:

Malaysia	Australia	Other Polynesian Islands	China and Japan
Philippine Islands	Solomon Islands and Bismarck	New Zealand	Africa
New Guinea	Archipel.	Hawaiian Islands	Macronesia
New Caledonia	Fiji and Tonga Islands	India	Madagascar Terr.

The species of New Caledonia were treated by Guillaumin² in 1940, and a key to them was published in 1948³. The Hawaiian species were revised by Sherff⁴ in

¹ Pritzel, E. In Engler & Prantl's, Nat. Pflanzenfam. ed. 2. 18a:273-281. 1930.

² Bull. Soc. Bot. Fr. 87:333. 1940.

³ Fl. Analyt. et Synopt. Nouv. Calédonie. Phanérogames. pp. 134-136. 1948.

⁴ Field Mus. Nat. Hist. Bot. Ser. 22:467. 1942.

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1942. A preliminary account of the African species by Cufodontis⁵ appeared in 1951, and a fuller revision⁶ in 1952. A study of the East Asian species by Gowda⁷ was published in 1951, and a criticism of this work by Li⁸, in connection with the Formosan species, followed in 1953. The species of the Malayan Archipelago will be revised by one of the authors of 'Flora Malesiana'⁹, and those of the Central Pacific Islands will be dealt with in A. C. Smith's "Studies of Pacific Plants"¹⁰. The species which occur in Australia and New Zealand are revised in this study, and an attempt is made to reconcile some of the divergent views of other workers.

HISTORY OF THE GENUS

William Dampier, navigator and sometime buccaneer, was the first European to collect a specimen of *Pittosporum* in the Australasian region. Between August 6 and September 2, 1699, he cruised along the northwest Australian coast in H.M.S. Roebuck, from Shark's Bay northward to 18° 21' S. latitude. The few specimens of plants he collected at Shark's Bay went to Dr. William Sherard and are preserved in the Sherardian Herbarium at Oxford, England. They were described by John Ray assisted by Sherard,¹¹ and Plukenet.¹² Among them was the species we now know as *Pittosporum phillyraeoides* DC. Linnaeus did not list the plant in his 'Species Plantarum' (1753) and although Robert Brown examined the Shark's Bay collection subsequent workers did not mention it.

The type specimens of the type species of the genus *Pittosporum* were collected by Banks and Solander, who accompanied Cook as naturalists on his first voyage of discovery. Between October 1769 and February of 1770 they collected four species in New Zealand, and in May and June of 1770 they obtained another species at Palm Island and Bustard Bay on the coast of Queensland, Australia. During the voyage Solander had written descriptions of the plants collected which were revised and systematically arranged prior to his death in 1782. Banks had prepared excellent plates to accompany his manuscript, but publication was delayed and finally abandoned. In 1788 Gaertner¹³ published the description of *Pittosporum* from the manuscript prepared by Solander, and described and illustrated the fruits and seeds of two species made available to him by Banks¹⁴.

The subsequent history of the collection of new species in Australia and New Zealand, like the history of botanical discovery in these regions, may be divided

⁵ Österr. Bot. Zeitschr. 98:105. 1951.

⁶ Fedde's Rep. Sp. Nov. 55:27. 1952.

⁷ Jour. Arnold Arb. 32:263. 1951.

⁸ Jour. Wash. Acad. Sci. 43:43. 1953.

⁹ Personal communication from Dr. C. G. G. J. Van Steenis, general editor of "Flora Malesiana".

¹⁰ Personal communication.

¹¹ Hist. Pl. Vol. 3, and Appendix. 1704.

¹² Almalth. Bot. 1705.

¹³ Fruct. et Sem. Pl. 1:286, t. 59. 1788.

¹⁴ The five species collected by Banks and Solander were: *Pittosporum tenuifolium* Gaertn., *P. umbellatum* Gaertn., *P. ralphii* Kirk, *P. cornifolium* A. Cunn., all from New Zealand, and *P. ferrugineum* Ait. from Australia.

into two periods: 1, the period of investigations by travellers or naturalists attached to voyages of discovery or survey; 2, the period of investigation by resident botanists. Dampier, Cook, d'Urville, Wilkes, Robert Brown, and J. D. Hooker are a few of the distinguished men who visited Australia and New Zealand during the first period. The second period followed when systematic white settlement of the two countries began. Bentham¹⁵, F. M. Bailey¹⁶, Maiden¹⁷, Lee¹⁸ and Willis¹⁹ have dealt adequately with the Australian collectors of both periods, and J. D. Hooker²⁰, Cheeseman²¹ and Cockayne²² have given full accounts of the New Zealand botanists.

The descriptions of species of *Pittosporum* from Australia and New Zealand are scattered widely in the extensive literature on the floras of these regions, but have been brought together from time to time by European and local workers. In 1839 Putterlick²³ recognised thirty-six species of which twelve were recorded from Australia and seven from New Zealand. Bentham²⁴, whose study was based on the extensive Australian collections of Robert Brown, Preiss, Sieber, Allan Cunningham, Ferdinand Mueller and others recognized nine species. J. D. Hooker²⁵ revised the New Zealand species in 1853 and again in 1864 and recognized thirteen species. His study was based on the extensive collections of Colenso, Sinclair, Dieffenbach, Buchanan, Bidwill, Richard and Allan Cunningham, Hector, Lyall, Travers, and others.

Hooker was far from satisfied regarding the status of several of the species, and wrote²⁶: "I have restored the var. *reflexum* of Fl. N.Z. as a different species, but with some doubt: better specimens are wanted of both"; and again²⁷, "It is with great reluctance that I add another *Pittosporum* to the series, already very difficult of discrimination, that consists of *tenuifolium*, *colensoi* and *fasciculatum*."

Kirk²⁸ published a revision of the New Zealand species in 1872, based on his own extensive collections and field observations. He did not have access to the early literature on the genus, or to the important collections at the Royal Botanic Gardens, Kew, but in spite of these handicaps he made a very valuable contribution

¹⁵ Fl. Austr. 1: pref. 1863.

¹⁶ Proc. Roy. Soc. Queensland 8:xvii, xlv. 1891.

¹⁷ Jour. & Proc. Roy. Soc. N.S.W. 42:60. 1908. 1st. Suppl. Rept. Austr. Assoc. Adv. Sci. 13: 224. 1912. 2nd Suppl. Jour. & Proc. Roy. Soc. N.S.W. 55: 150. 1921.

¹⁸ Early explorers in Australia. 1925.

¹⁹ Vict. Nat. 66^{4,6,7}. 1949.

²⁰ Handb. N.Z. Fl. Pref. 1864-1867.

²¹ Man. N.Z. Fl. p.xi. 1906; ed. 2. p.xv. 1925.

²² Vegetation of New Zealand. In Die Vegetation der Erde 14:8. ed. 2. 1928.

²³ Syn. Pittosp. pp. 5-18. 1839.

²⁴ Fl. Austr. 1: 109. 1863.

²⁵ Fl. Nov. Zel. 1: 21. 1853; Handb. N.Z. Fl. p.18. 1864, and p. 725. 1867.

²⁶ loc. cit. p.21. 1864.

²⁷ loc. cit. p.725. 1867.

²⁸ N.Z. Inst. Trans. & Proc. 4:260. 1872.

to our knowledge of the New Zealand species. Cheeseman²⁹, who worked under similar difficulties, recognized nineteen species in 1906 and twenty-three in 1925, but expressed doubts regarding the status of many of these entities.

The most recent study which is of importance to us is that of the small-leaved species of *Pittosporum* in New Zealand, published by Laing and Gourlay³⁰ in 1935. This was based on extensive field observations and a considerable number of specimens cultivated in the authors' gardens, and includes complete descriptions of seedling and juvenile stages. They observed the similarity of one of the small-leaved New Zealand species of *Pittosporum* to the Australian species of *Bursaria* but left the question of nomenclature changes to future workers. Pax³¹ treated the genus as a whole for the 'Die Natürlichen Pflanzenfamilien' in 1891 and recognised the species described by Bentham for Australia and by J. D. Hooker and Kirk for New Zealand. Similarly, Pritzel³², in the second edition of 'Die Natürlichen Pflanzenfamilien', adopted the Australian species from Bentham and subsequent authors, and the New Zealand species from Cheeseman, with little change.

ECONOMIC USES

From the wealth of observation published on the uses of different species of *Pittosporum* two generalizations can be made: (1) that certain medicinal and poisonous properties are common throughout the range of the genus; (2) that these properties were known to several primitive races of people who lived in communities which were widely separated, if not completely isolated.

The Australian aborigines soaked the seeds and pulp of the fruit of *P. phillyraeoides* in water and used the bitter infusion internally for pains and sprains³³. The Filipinos used a decoction of the leaves of *P. pentandrum* as an aromatic bath after childbirth, and the powdered bark of the same tree as a febrifuge and for bronchitis. They also used the fruits of *P. resiniferum* as a universal medicine³⁴. The Malaysians applied the leaves and roots of *P. ferrugineum* as poultices in the treatment of malaria³⁵, and some South African natives employed the bark of *P. viridiflorum*³⁶ as a febrifuge and as a bitter emetic. Again, on Réunion Island the natives used the bark and leaves of *P. senecio* in medicine³⁷.

The Malaysians macerated the leaves and fruit of *P. ferrugineum* for fish poison³⁸, and the Javanese treated *P. ferrugineum* and *P. javanicum* for the same

²⁹ Man. N.Z. Fl. pp. 51, and 1134. 1906; ed. 2, p. 486. 1925.

³⁰ Trans. Roy. Soc. N.Z. 65:44. 1935.

³¹ Engler & Prantl, Nat. Pflanzenfam. 3(2a):106. 1891.

³² loc. cit. ed. 2. 18a:265. 1930.

³³ Maiden, For. Fl. N.S.W. 3¹:161. 1908.

³⁴ Valenzuela, Concha and Santos. Jour. Philipp. Pharm. Assoc. 34:34. 1947.

³⁵ Burkill, Dict. Econ. Prod. Malay Penin. 2:1763. 1935.

³⁶ Githens, Drug Pl. Afr. p.100. 1949.

³⁷ Niederlein, Resources Veg. des Colon. Franc. p.55. 1902.

³⁸ Burkill, loc. cit. 1935.

purpose³⁹. The Fijians used the fruits of *P. arborescens*, *P. brackenridgei*, and *P. rhytidocarpum* as a fish poison, the fruits of *P. rhytidocarpum* as a dye, the leaves of *P. arborescens* as a remedy for stomach troubles, and the bark and leaves of *P. arborescens* and *P. brackenridgei* for witchcraft. A cherished sheet of *P. arborescens* in the herbarium of the Department of Agriculture, Suva, Fiji, is from a plant which was "Exhibit A" at the trial of a poisoner charged with ritual murder.

It is possible that these medicinal and poisonous properties will be of economic value in the future. For example, the bitter properties of *P. phillyraeoides* (Australia) and *P. viridiflorum* (South Africa) have been mentioned. Since the dawn of history all sorts of virtues have been ascribed to bitter or "strong" medicine, but bitters still have a place in medicine as general tonics, in the control of diarrhoea, and in wound dressings.

The presence of saponins has been reported by a number of workers. Klein⁴⁰ states that the following species contain the saponin "pittosporin" of unknown formula. He gives no reference, but the information is probably taken from Greshoff⁴¹.

REGION	SPECIES	MATERIAL TESTED
Sino-Japanese Region	<i>Pittosporum tobira</i>	Leaves
Madeira-Teneriffe	<i>Pittosporum coriaceum</i> <i>Pittosporum densiflorum</i>	Leaves and bark Leaves
Malayan Archipelago	<i>Pittosporum javanicum</i>	Bark
South Africa	<i>Pittosporum floribundum</i> <i>Pittosporum viridiflorum</i>	Bark Bark
Australia	<i>Pittosporum erioloma</i> <i>Pittosporum phillyraeoides</i> <i>Pittosporum rhombifolium</i> <i>Pittosporum undulatum</i>	Leaves Fruit Leaves Leaves and bark
New Zealand	<i>Pittosporum cornifolium</i> <i>Pittosporum crassifolium</i> <i>Pittosporum eugenioides</i> <i>Pittosporum buttonianum</i>	Leaves Leaves Leaves Leaves

³⁹ Hayne, Nutt. Plant. Ned. Ind. p. 688. 1927.

⁴⁰ Handbuch der Pflanzenanalyse. 3²:1135. 1932.

⁴¹ Kew Bull. p. 414. 1909.

The presence of saponins probably accounts for most of the medicinal and poisonous properties of the species. Githens⁴² says:

The saponins constitute a very large and diverse group of glucosides which have the property of causing foaming when added to water. [*P. coriaccum* and *P. viridiflorum* are known as soap substitutes in their native countries.] They find an extensive use in shampoos, toothpastes and similar cosmetic preparations. Some have no marked action on the body, but many of them induce nausea or vomiting. This is accompanied by increased secretion in the respiratory passages and a greater fluidity of the mucus, leading to loosening of coughs or expectorant action. The nausea is often accompanied by sweating leading to lowering of febrile temperature. Saponins are therefore used as emetics, expectorants and febrifuges. Many saponins act on the gills of fish and interfere with respiration and are therefore used as fish poisons. A few saponins are locally irritant and act as purgatives . . . some (sapotoxins) cause death.

Saponins have been found suitable for insecticides, but neither the Department of Insecticides at Rothamstead Experimental Station, England, nor the Section for Insecticide Investigations at the U. S. Department of Agriculture Research Station, Beltsville, Md., has examined any species of *Pittosporum*. The only information I have on their insecticidal properties is to be found in "A Survey of Plants for Insecticidal Activity" by Heal and others⁴³. These workers found that aqueous extracts of the branches, leaves, and roots of *P. senacia* were toxic to American cockroaches when injected into the bloodstream, but were inactive against German cockroaches and milkweed bugs. Alcohol and petroleum ether extracts of *P. senacia* branches leaves were toxic to black carpet beetles, but non-toxic to other insects tested. An extract of *P. viridiflorum* bark was non-toxic to all insects tested. *Pittosporum ferrugineum* of Malaya and Australia, and *P. arborescens*, *P. brackenridgei* and *P. rhytidocarpum* of Fiji appear, from their record as fish poisons, to be more promising than the species tested.

The essential oils of several species have been examined and described, and the papers are listed:

Malayan Archipel.....	{	<i>Pittosporum monticolum</i>	A. J. Altee. in Pharm. Weekblad, 74:666. 1937
		<i>Pittosporum resiniferum</i>	I. Garcia-Reyes, in Rev. Filip. Med. Farm. 28:448. 1937.
Australia.....		<i>Pittosporum undulatum</i>	J. W. Cornworth & J. C. Earl, in Jour. Roy. Soc. N.S.W. 72:249. 1939.
New Zealand.....	{	<i>Pittosporum eugenoides</i>	C. L. Carter & W. V. Heazlewood, in Jour. Soc. Chem. Ind. 68: 34. 1949.
		<i>Pittosporum tenuifolium</i>	A. J. Calder & C. L. Carter, loc. cit. 68:355. 1949.

⁴² Githens, loc. cit. 1949.

⁴³ Lloydia 13:89. 1950.

Essential oils⁴⁴ usually are the source of scent in flowers, and have many uses as flavors and condiments in food. Frequently they have the property of checking bacterial growth and are used for food preservatives, and even as wound dressings. They are also valuable in medicine to regulate intestinal movements and for respiratory, kidney and urinary infections. In 1889 Maiden⁴⁵ recommended the cultivation of *P. undulatum* on a commercial scale for its essential oil, but his suggestion has never been followed, and the possibilities of this and other species remain unexplored.

The gum-resins of *P. bicolor*, *P. rhombifolium* and *P. undulatum* of Australia and of *P. eugenoides* and *P. tenuifolium* of New Zealand have been described by Maiden⁴⁶, who suggested that they might be found useful in medicine.

The woods of the Australian species have been described by Mueller⁴⁷, Bailey⁴⁸ and Maiden⁴⁹, and the woods of the New Zealand species have been dealt with by Kirk⁵⁰ and others. They are not available in sufficient size or quantity for commercial use but are much esteemed for special purposes. The wood of *P. undulatum* is preferred by some to any other timber for golf sticks⁵¹. The wood of *P. bicolor*, which was once used for clubs or "waddies" by the aborigines of Tasmania, is now much esteemed for axe handles and billiard cues⁵². The replacement of "waddies" by billiard cues will be deplored by all lovers of the truncheon and shillelagh.

Pittosporum has made a small but valuable contribution to horticulture. The cultivation of species of *Pittosporum* began when *P. coriaceum* was brought to England from Madeira in 1787 and introduced into gardens by James Webster; *P. undulatum* was introduced into England from Australia by Sir Joseph Banks about two years later; and *P. tobira* was sent to Kew from Canton, China, in 1804. Splendid living collections are maintained today at the Royal Botanic Gardens, Kew, the Villa Thuret, in southern France, and Golden Gate Park, San Francisco, California. Many Australian and New Zealand species are represented in these collections and are grown in the surrounding districts as street trees, garden ornamentals, hedge plants, and shelter trees. The Australian *P. undulatum* is probably the most widely cultivated and has been reported in gardens in Ceylon, Italy, the Azores, France, England, the United States (Florida and California), Bermuda, Hawaii, India, China, New Zealand and, of course, Australia. In the Azores it was introduced as a shelter tree for the orange groves and is now naturalized. In Bermuda and Hawaii it has also become naturalized and is an attractive addition to the local flora.

⁴⁴ Finemore, H. The essential oils. pp. 347-349. 1926.

⁴⁵ Useful Nat. Pl. Austr. p.292. 1889.

⁴⁶ Proc. Austr. Assoc. Adv. Sci. 4:289. 1893.

⁴⁷ Select Extra-Trop. Pl. p.258. 1881.

⁴⁸ Queensland Woods. p.11. 1888.

⁴⁹ Useful Nat. Pl. Austr. p.588. 1889.

⁵⁰ N.Z. Inst. Trans. & Proc. 4:260. 1872.

⁵¹ Maiden, For. Fl. N.S.W. 7:129. 1920.

⁵² Maiden, For. Fl. N.S.W. 8:47. 1923.

The widespread use of the Australian and New Zealand species in horticulture has been accompanied by the usual nomenclatural problems. Horticulturists have created, and persist in using, several specific epithets which have been ignored or reduced to synonymy by taxonomists concerned only with the "wild forms". I have attempted to solve the nomenclatural problems by citing published horticultural names in the synonymy of the species concerned and in the discussion following the description.

TAXONOMIC CRITERIA

The principal criteria for the classification of the Australian and New Zealand species of *Pittosporum* are based on comparative morphology and geographic distribution. The chromosome number of only one species, the Chinese *P. tobira* ($2n = 24$), is known⁵³, and the embryology of the genus has not been investigated⁵⁴. The anatomy of thirty-six species of *Pittosporum*, and a representative of each of the allied genera, *Hymenosporum*, *Bursaria*, *Sollya*, and *Citriobatus*, has been examined by Guenot, who commented:⁵⁵ "La structure anatomique du genre *Pittosporum* s'est montrée dans les espèces que nous avons examinées d'une constance remarquable."

Gowda⁵⁶ examined the pollen of twenty-six species of *Pittosporum* and a representative of each of the other genera in the family, and found that they varied in size but did not show any marked difference in form and sculpture. Lucy Watson-Smith⁵⁷ has informed me that the New Zealand species vary in size and thickness of the exine but generally are very much alike. In the preceding chapter on economic uses I mentioned that certain chemical properties of the genus are remarkably constant.

A study of living and herbarium specimens has convinced me that *Pittosporum* is an assemblage of very homogeneous forms and that many of its morphological characters are constant throughout its range from Hawaii to South Africa. All the evidence suggests that it is a tropical and subtropical genus which is most specialized and reduced at the extreme limits of its distribution, especially at the southern boundaries in Australia and New Zealand.

MORPHOLOGY

SHOOT SYSTEM:

The Australian and New Zealand species are evergreen trees and shrubs with verticillate and simple branching. Gowda⁵⁸ described the behaviour of the leading shoot as follows:

⁵³ Darlington, C. D. and Janaki Ammal, E. K. Chromosome atlas of cultivated plants. p. 112. 1945.

⁵⁴ Johansen, D. A. Plant embryology. p. 174. 1950

⁵⁵ Guenot, J. F. Contribution à l'étude anatomique des Pittosporacées. Doct. Diss. Univ. Paris. Ser. A. No. 523, p. 52. 1906.

⁵⁶ Jour. Arnold Arb. 32:277. 1951.

⁵⁷ Personal communication.

⁵⁸ loc. cit. p. 265. 1951.

1. Vegetative in the first year.
 - a. Producing terminal leafy inflorescences in the second year and also a new leading vegetative shoot or shoots from the lower axils; or
 - b. Producing leafless pseudoterminal inflorescences the second year from the buds congested at the apex, and also a new leading vegetative shoot or shoots.
2. Vegetative and terminating in an inflorescence the first year, and the second year producing a new leading vegetative shoot or shoots from its lower axils.

A plant of the Australian *P. undulatum* was observed in the Linnaean house of the Missouri Botanical Garden from February 1952 until April 1953. In February inflorescences developed in a terminal position on leading shoots. During April and May buds appeared in the axils of the leaves beneath the inflorescences, and some of these developed rapidly and assumed a leading position while others developed more slowly and formed a whorl of lateral branches. Similar behaviour was observed in the Chinese *P. tobira* and on both plants two phases of growth, reproductive and vegetative, were accomplished in the growing season.

The plants bore female flowers which were not fertilized, and the dead flowers were forced to one side and shed when an axillary shoot assumed a leading position. On several branches of both plants one or two axillary vegetative shoots developed at the same time as, and immediately below, the terminal inflorescences. In several instances one of these vegetative shoots immediately assumed a leading position and the inflorescence was left behind in a lateral position. On other branchlets the vegetative shoots formed an irregular whorl and the inflorescence was left behind in a terminal position.

An examination of herbarium material of *P. undulatum* showed that the vegetative buds remain dormant in the axils of the subtending leaves when fruit develop and the cluster of fruit persists for some time as a terminal structure. Herbarium material of *P. umbellatum*, *P. tenuifolium*, *P. crassifolium*, *P. cornifolium*, and *P. dallii* showed that where a terminal inflorescence developed fruit, the fruit stalks were occasionally forced to one side by the leading shoot and persisted in a lateral position.

Agnes Arber⁵⁰ has remarked that in shoot systems, "the subordination of parent shoots to lateral shoots is, indeed, quite common; it is the essential feature of all sympodial and cymose branching."

The development of the leading vegetative shoot prior to the inflorescence shoot involves a change in timing which has occurred in the allied Australian genus *Sollya*. In *S. heterophylla* the inflorescence develops in a lateral position but is not subtended by a leaf. There is a leaf on the side of the shoot opposite to the inflorescence, however, indicating that the shoot above the inflorescence is really a lateral axillary structure.

In *Pittosporum divaricatum* and *P. crassicaule* of New Zealand the branchlets are almost spinose, but bear leaves and occasionally an inflorescence. Spines are

⁵⁰ The natural philosophy of plant form. p.94. 1950.

well developed in the Australian *P. o'reillyanum* and the allied Australian genera *Bursaria* and *Citrobatus*, and their derivation from short shoots is indicated by the occasional presence of leaves on them.

In the New Zealand *Pittosporum divaricatum*, *P. crassicaule*, and *P. anomalum* the flowers are borne on "arrested branchlets" which may attain several millimetres in length. These are lateral structures and appear to be miniature forms of the reproductive shoots on which the flower stalks are borne in many other species.

In the Australian *P. phillyraeoides* and *P. bicolor*, and in the New Zealand *P. obcordatum* and *P. rigidum*, the inflorescence consists of a solitary flower, or a fascicle of flowers, which is usually borne in the axil of a leaf. *Pittosporum phillyraeoides* rarely has several flowers in a cyme, and *P. obcordatum* and *P. rigidum* frequently have flowers on minute arrested branchlets. The New Zealand *P. tenuifolium* and *P. buttonianum* bear both terminal and axillary inflorescences which consist of a fascicle of flowers or of a solitary flower.

In all species mentioned the flowers may be considered as terminal on a shoot which is reduced and sometimes is represented only by the scales at the base of the flower stalks. Occasionally, in *P. tenuifolium* and *P. buttonianum* the shoot is well developed and bears a whorl of cataphylls or 1-2 leaves beneath the terminal fascicle of flowers. Rarely, the subtending cataphylls and leaves are suppressed and the inflorescence appears to be compound. Other aspects of this reduction in the reproductive shoot are discussed below.

The presence of terminal inflorescences, axillary inflorescences, and of both terminal and axillary inflorescences is fairly constant within a species or subspecies and is a valuable criterion for classification. However, it must be borne in mind that the inflorescence may be pushed from a terminal to a lateral position by the development of a leading shoot. Furthermore, in some species several reduced forms of the fertile shoot (e.g. a cyme, fascicle, or solitary flower) may be found together on a branchlet.

LIFE FORMS:

The life forms of the Australian and New Zealand species and subspecies, according to the system of Du Rietz⁶⁰, are summarized in the following table:

In compiling this table difficulty has been experienced in fitting the species to the various categories defined by Du Rietz. His definition of "trees" is holoxyles with a distinct main trunk remaining unbranched in its lower part", and of "shrubs," "holoxyles higher than 0.8 m., not developing a distinct main trunk, with the stem branched from its basal part above or below the soil surface". Some species of *Pittosporum* develop both a main trunk and branches from the base. *Pittosporum undulatum*, for example, when grown in an open situation usually has branches from the base as well as a main trunk. Difficulty has also been experienced with the size classes of Du Rietz. Again *Pittosporum undulatum* may

⁶⁰ Life forms of terrestrial flowering plants. Acta Phytogeogr. Suec. 31. 1931.

Life Form	Australian	Norfolk and Lord Howe Islands	New Zealand	
	BIVALVAE	TRIVALVAE	BIVALVAE	TRIVALVAE
Tall trees (8 - 30 m. in height)	6	..	2	2
Low trees (2 - 8 m.)	1	2	4	3
Dwarf trees (0.8 - 2 m.)	..	..	1	..
High shrubs (2 - 8 m.)	4	..	3	2
Ordinary shrubs (0.8 - 2 m.)	..	..	1	..
Dwarf shrubs (under 0.8 m.)	..	..	2	..
Epiphytic shrubs	..	..	2	..

be cited as an example: in barren exposed localities it is a shrub 2-3 m. high but in favorable situations it is a tree 10-30 m. tall. Similarly, *P. bicolor*, *P. rhombifolium*, and *P. crassifolium* are very variable in habit and size.

In spite of these difficulties the summary does show: (1) that the New Zealand species of the series TRIVALVAE are conservative in form; (2) that the New Zealand species of the series BIVALVAE are more diverse in shrub forms; and (3) that the Australian species of the BIVALVAE are a relatively conservative group.

The Australian species belonging to genera allied to *Pittosporum* have 2-valved fruits, and if these were included in the table the number of shrub species would be much higher, and the number of life form classes would be increased by the addition of dwarf-shrubs, dwarf half-shrubs, and twiners with a woody base.

Although the life forms of members of the Pittosporaceae have evolved along closely parallel lines in Australia and New Zealand, the New Zealand species are placed without difficulty in the genus *Pittosporum* while the Australian species are so specialized in other characters that they are classified in separate genera. A possible explanation of the different rates of evolution in the two countries is given later.

Laing and Gourlay⁶¹ considered that the small-leaved New Zealand species of the BIVALVAE are a natural group and commented:

It should first be noted that all the species dealt with . . . are highly polymorphic in length and rigidity of branchlets, leaf shape and size, and in habit generally. In addition to the polymorphic mature plant, each of the species . . . has also a distinct juvenile and shade form, differing in habit, leaf size and shape, from the corresponding adult plant. Sometimes there is more than one adult form, and the juvenile may go through many changes.

⁶¹ Trans. Roy. Soc. N.Z. 65:46. 1935.

There are a number of species, however, which lie between the two extremes represented by Laing and Gourlay's polymorphic small-leaved section of BIVALVAE and the more conservative members of the BIVALVAE and TRIVALVAE. For example, *Pittosporum turneri* is a shrub or tree 2-9 m. tall, with sharply divaricating and matted branchlets at the juvenile stage and on the lower part of the adult stem, and ascending branches on the upper part of the stem. The leaves are relatively small below and large above, and the plant combines the distinguishing characters of the two sections suggested by Laing and Gourlay.

Cockayne and Allan⁶² recorded about 200 New Zealand species as showing more or less strongly marked dimorphy or even polymorphy as they progress from the juvenile to the adult stage, and they suggested that an explanation based on hybridism and the "somatic segregation" in hybrids of chimaeras of various types might be the correct one. There is, however, no evidence to support their hypothesis.

ONTOGENETIC DEVELOPMENT OF THE SHOOT:

The vegetative shoot develops from a bud which is protected by cataphylls. The term "cataphyll"⁶³ is used here to include both bud scales and transitional leaves. Usually the latest-formed cataphylls become quite leaf-like but with the elongation of the shoot they are shed and only a whorl of leaves near the apex of the shoot matures. The sequence of cataphylls from one whorl of mature leaves to the next is illustrated in fig. 1. for the Australian *P. undulatum*, the New Zealand *P. umbellatum*, and the Chinese *P. tobira*.

Usually the cataphylls are missing from herbarium specimens but their scars have been found in most species of *Pittosporum* that I have examined. In the allied Australian genus *Hymenosporum* the cataphylls are shed, but in *Sollya*, *Bursaria*, *Pronaya*, *Billardiera*, *Citriobatus*, *Cheiranthra*, and *Marianthus* they are retained.

Stebbins⁶⁴ and others have remarked that the presence of an apical meristem and the serial differentiation of organs result in two types of ontogeny; one is that of the various lateral appendages, starting from the time when they become differentiated from the apical meristem of the shoot, and the other is that of the embryo and seedling. Agnes Arber⁶⁵ pointed out that recent work by Miller and Wetmore⁶⁶ showed that the development of the shoot from the meristematic apex is merely a modification of the original pattern in the relevant part of the embryo. The embryo has not been investigated, but there are many observations on the development of *Pittosporum* seedlings and juveniles.

Generally variations in size and shape are more marked in seedling and juvenile leaves than in the cataphylls between two whorls of mature leaves, but the resemblance between the two ontogenies is marked.

⁶² Jour. Ecol. 15:239, 245. 1927.

⁶³ Foster, in Amer. Jour. Bot. 16:475. 1929.

⁶⁴ Variations and evolution in plants. p. 488. 1950.

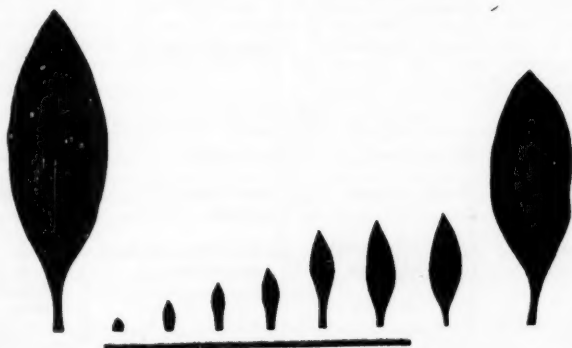
⁶⁵ The natural philosophy of plant form. p. 162. 1950.

⁶⁶ Amer. Jour. Bot. 33:1. 1946.



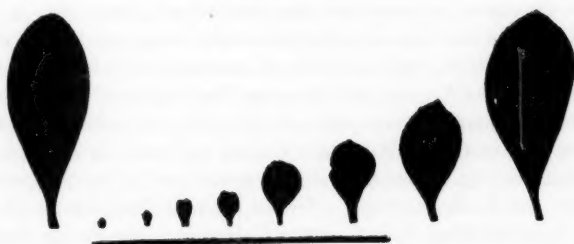
P. UMBELLATUM

NEW ZEALAND



P. UNDULATUM

AUSTRALIA



P. TOBIRA

ASIA

Fig. 1. Sequence of cataphylls and leaves of three species of *Pittosporum*. Previous mature whorl of leaves at left; new whorl at right; caducous cataphylls indicated by horizontal black line. About one-third natural size. Further explanation in the text.

The following summary of seedling, juvenile, and adult foliage in representative Australian and New Zealand species of *Pittosporum* and in *Billardiera longiflora* is based on the descriptions of Lubbock⁶⁷, Cockayne⁶⁸, Sainsbury⁶⁹, Hardy⁷⁰, Laing and Gourlay⁷¹, as well as my own observations.

Species	Seedling leaves	Juvenile leaves	Adult leaves
Australia			
<i>P. pbillyracoides</i>	Entire, lanceolate-oblong	As for adult	Entire, linear-oblong
<i>P. undulatum</i>	Entire, lanceolate-oblong	As for adult	Entire, elliptic-oblong
<i>B. longiflora</i>	Entire, linear	Trilobed, obovate	Trilobed, lobes serrate, ovate
New Zealand			
<i>P. tenuifolium</i>	Entire, ovate	As for adult	Entire, oblong-ovate
<i>P. umbellatum</i>	Entire, obovate	Lobed, pinnatifid, obovate	Entire, elliptic
<i>P. divaricatum</i>	Irregularly double, serrate, linear	Lobed, oblong or obovate to linear	Entire or dentate, crenate or lobed, linear-oblancoate to linear-oblong
<i>P. eugenioides</i>	Entire, lanceolate-elliptic	Variouly notched at base, oblong-elliptic	Entire, oblong-elliptic

From the above summary and the descriptions given later, it is clear that marked changes in seedling, juvenile, and adult foliage are due to differences in size and general outline, and frequently to variation in the leaf margins.

Following Arber⁷², I am using the term "heterophylly" to describe the occurrence of two or more different types of leaf upon one individual. Heterophylly has been reported in almost all the New Zealand species of *Pittosporum*. It is slight in the TRIVALVAE (e.g. *P. tenuifolium*) but is well marked in the BIVALVAE (e.g. *P. umbellatum* and *P. divaricatum*). Several heterophyllous species of *Pittosporum* have been reported from New Caledonia⁷³, but none are known from Australia. The allied Australian genera, *Pronaya*, *Marianthus*, and *Billardiera* have species with

⁶⁷ A contribution to our knowledge of seedlings. p. 200. 1892.

⁶⁸ N.Z. Inst. Trans. & Proc. 31:362. 1899; and 33:265. 1901.

⁶⁹ N.Z. Inst. Trans. & Proc. 54:572. 1923.

⁷⁰ Proc. Roy. Soc. Vict. 28:240. 1916.

⁷¹ Trans. Roy. Soc. N.Z. 65: 44. 1935.

⁷² Water plants. p.143. 1920.

⁷³ Guillaumin, in Bull. Mus. Hist. Nat. Paris 25:214. 1919.

lobed or notched leaves, however, and their resemblance to juvenile forms of the New Zealand species of *Pittosporum* is striking.

Distinct sun and shade forms in *P. divaricatum*, *P. crassicaule*, and *P. anomalum* have been described by Cockayne⁷⁴, and Laing and Gourlay⁷⁵; and Michie has supplied me with sun and shade forms of *P. pimeleoides* var. *major*. It is clear from the records and specimens that leaves exposed to the sun tend to be entire, and that shaded leaves are variously lobed, toothed, and pinnatifid; but exposure and shade are obviously not the cause of heterophylly. Stebbins⁷⁶ discussed heterophyllous leaves from the ecological viewpoint but admitted that similar lobed and pinnatifid leaves in *Quercus* had no apparent selective value. Ashby⁷⁷ studied the changes in size and shape from leaf to leaf on a shoot of *Ipomoea caerulea* and remarked:

On the basis of these fragments of evidence it is suggested that lobing is determined very early in leaf ontogeny by a growth substance which changes in concentration or composition during development, . . . and which is suppressed at low light intensities and also in short days with uninterrupted nights.

Elsewhere⁷⁸, he summarized past research as follows:

In some plants no correlation has been discovered between leaf shape and external conditions. In these plants (e.g. species of *Ipomoea* and *Hedera*) leaf shape is a function of the age of the plant and the position at which the leaf arises. Heteroblastic^[79] development is presumably controlled by unknown internal factors.

Both leaf shape and rate of heteroblastic development are influenced by genes. For *Gossypium* the effects of some specific genes on heteroblastic development have already been worked out.

In the New Zealand *P. umbellatum* the change from lobed and pinnatifid leaves is abrupt, but in *P. virgatum* it is gradual; in fact, lobed leaves are frequently found in the adult foliage. There are not two phases, juvenile and adult, in this species, but a series of phases in which the leaves differ markedly in size and form. Ross Michie, of Kaitia, N.Z., a keen amateur botanist, has a number of plants of *P. virgatum* in cultivation on which two, three and four types of foliage are present at different levels on the trunk, and he observes that some plants develop entire leaves after the first phase of lobed and pinnatifid leaves, while others pass through two or three more or less distinct leaf forms before reaching the adult foliage.

Leaf forms of juvenile and adult plants of *P. umbellatum*, *P. virgatum*, *P. patulum*, *P. turneri* and *P. pimeleoides* are illustrated in fig. 2, and measurements of their flowers and fruits are given in the chapter on Taxonomy. There is some similarity between the adult leaves of *P. pimeleoides*, and the juvenile leaves of *P. patulum*, *P. turneri*, and *P. virgatum*, and some resemblance between the adult

⁷⁴ Rept. Austr. Ass. Adv. Sci. 13:219. 1912.

⁷⁵ Trans. Roy. Soc. N.Z. 65:44. 1935.

⁷⁶ Variation and evolution in plants. p.490. 1950.

⁷⁷ New Phytol. 49:386. 1950.

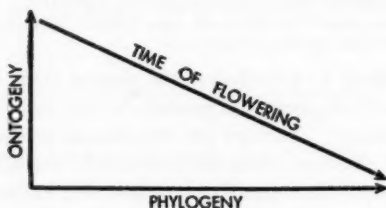
⁷⁸ loc. cit. 47: 174. 1948.

⁷⁹ The term "heteroblastic" is used by Ashby in the sense given it by Goebel (*Organographie der Pflanzen*, ed.1. p.123. 1898) and is synonymous with "heterophyllous" in this discussion.

leaves of *P. patulum* and *P. turneri* and the juvenile leaves of *P. virgatum*. There is closer similarity between the adult leaves of *P. virgatum* and the juvenile leaves of *P. umbellatum*. In habit, *P. pimeleoides* is a slender shrub to 2.5 m. tall; *P. umbellatum* is a spreading tree to 10 m. tall; and *P. virgatum*, *P. patulum*, and *P. turneri* are trees intermediate in height between these two extremes.

In size of inflorescence, flowers and capsules, the species show a similar gradient from *P. umbellatum* to *P. pimeleoides*. In other morphological characters and in their geographical ranges the five species are distinct; but a comparison of leaf forms, flowers, and capsules suggests that they may be of common origin and represent a series in which increase, or more probably reduction, in size has been of evolutionary significance.

Flowering on semi-juvenile and shade forms has been observed in *P. virgatum*, *P. turneri*, *P. patulum*, *P. pimeleoides*, *P. pimeleoides* var. *major*, *P. divaricatum*, *P. obcordatum*, *P. crassicaule*, and *P. anomalum*, and the phenomenon is not rare in heterophyllous species⁸⁰. The possibility that some of the reproductive juvenile forms have become permanently fixed during the history of *Pittosporum* is suggested to account for the resemblance in leaf form and leaf ontogeny, and may also be relevant in the comparative interpretations of plant forms in the family. In the diagram below I hesitantly present a representation of the hypothesis, adapted from De Beer⁸¹.



Takhtajan⁸² discussed similar phenomena in higher plants in relation to phylogeny, and concluded that:

In the evolution of the organism new characters arise as hereditary changes of the most varied stages of their development, beginning from the initials and terminating with the last phases. The most differentiated and, consequently, least plastic are the last stages of the development of an organism or organ. The latter end, particularly the terminating stages, can produce small insignificant variations only. At the last phases arise asymmetry of the leaf, zygomorphy of the flower, the increase and decrease in the size of the organs, . . . The changes in the terminating stages of development give rise to various kinds of regressive phenomena as well. Having set in the last stages of development the change can gradually move on deep into more earlier stages of ontogenesis. Just in this way great evolutionary transformations of the organs usually take place.

⁸⁰ Cockayne, Vegetation of New Zealand, In Die Vegetation der Erde. ed. 2. 14:140. 1928.

⁸¹ Embryos and ancestors, ed. 2. p. 32. 1951.

⁸² Trans. Molotov State Univ. Erevan 22:168. 1943.

Regarding embryological investigations from the standpoint of comparative morphology Jepsen, Mayr, and Simpson⁸³ remarked:

Morphological embryologists are agreed on recognizing a principle of *heterochrony*, alteration of the sequence of ontogenetic stages in the phylogeny of a structure. Obviously this is merely a morphologist's phrasing of the geneticists' conclusion that mutation may alter the relative velocity of ontogenetic processes.

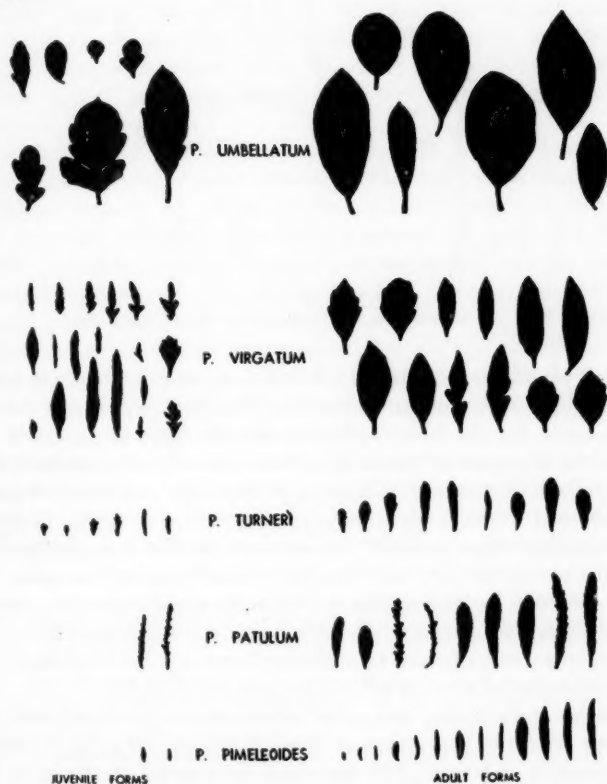


Fig. 2. Variation in leaf forms of five species of *Pittosporum*: juvenile forms at left; adult forms at right. One fourth natural size. Further explanation in the text.

THE INFLORESCENCE:

The basic unit of the inflorescence of *Pittosporum* is the cyme. In *P. undulatum* (fig. 3) the flower-stalks bear one to four flowers. The first flower to open is the terminal one, after which flowering is frequently from the base of each flower-stalk upwards, although the order is variable.

⁸³ Genetics, paleontology and evolution. p.71. 1949.

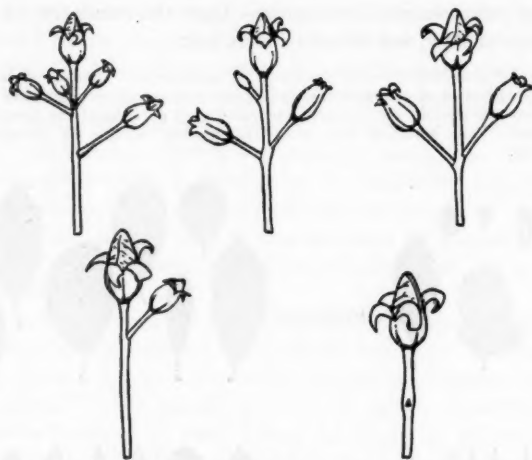


Fig. 3. Variation in the inflorescence of *P. undulatum*, Australia. $\times 1\frac{1}{2}$.

Gowda⁸⁴ placed the series TRIVALVAE before the series BIVALVAE in his key to the genus as plants of the former have certain characters (e.g. large 3-valved capsules, many seeds, funicles from the base to near the apex of the capsule valve) from which the characters of the BIVALVAE were derived. He considered that the evolution of the inflorescence in the genus "is from the well branched paniculate [i.e. paniculiform] to the simple cymose type and eventually to the solitary flower with all intermediate stages present." But none of the East Asian or New Zealand species of the TRIVALVAE have well-branched paniculiform inflorescences. In the Australian and New Zealand species the following trends have been recognised:

1. Reduction from a cyme to a solitary flower, e.g. *P. undulatum*.
2. Reduction from a fascicle to a solitary flower, e.g. *P. tenuifolium*.
3. Condensation of a compound inflorescence, e.g. *P. dallii*.

Presumably the spreading compound inflorescence of *P. ferrugineum* and its allies has been derived by aggregation of fertile shoots and reduction of subtending leaves to cataphylls or bracts. The increase in the number of flowers in the inflorescence has been balanced by reduction in the size of the capsule and in the number of seeds.

PUBESCENCE:

Hairs are most common on young shoots, leaves, and inflorescences; and persist on petioles and undersides of leaves, pedicels, sepals and ovaries. The two main types in the Australian and New Zealand species are icacinaceous and malpighaceous hairs as defined by Heintzelman and Howard⁸⁵. Forms intermediate

⁸⁴ loc. cit. p.271. 1951.

⁸⁵ Amer. Jour. Bot. 35:43. 1948.

between the two types are found. The absence of hairs, or the presence of hairs on parts usually bare, is a criterion for the recognition of particular species or subspecies. Hair color is also useful in the recognition of several species, e.g. *P. buttonianum*, although in other species it is most variable, e.g. *P. bicolor*.

THE FLOWER:

Kirk⁸⁶ reported dimorphic flowers in several New Zealand species of *Pittosporum*, and Petrie⁸⁷ described male and female flowers of *P. cornifolium*. Several notes on the sexual behaviour of the Australian species of *Pittosporum* were published by Maiden⁸⁸, and the pollination of the New Zealand species was discussed by Thomson⁸⁹.

In most of the Australian and New Zealand species I have found flowers which appear to be functionally unisexual. The male flowers have weakly capitate to truncate stigmas, long styles, slender ovaries, oblong anthers 2-4 mm. long borne on slender filaments. Usually the anthers are level with the stigma or exerted. The flowers which I think may be female have 2-, 3- or 4-lobed capitate stigmas, slightly shorter styles, plumper ovaries, apparently abortive, sagittiform anthers 1-2 mm. long, borne on filaments 1 mm. or more broad at the base, tapering distally. Usually the anthers are borne below the stigma. Flowers with oblong, apparently functional anthers 3-4 mm. long, capitate stigmas, and plump ovaries occur (i.e. hermaphroditic), as do flowers with 4 functional anthers 3-4 mm. long and one apparently abortive anther 1-2 mm. long.

Ross Mitchie, of Kaitaia, N. Z., has observed the flowers of a number of species over a period of years and considers that some plants have female and others male flowers, but the female plants sometime shed a little pollen and the males occasionally set a few fruit. In a letter to Dr. Woodson⁹⁰ I recently recorded my own studies as follows:

I have observed four self-sown trees of *Pittosporum tenuifolium* ssp. *tenuifolium* for three years in my garden at Blockhouse Bay, New Zealand, where there is an acre of rapidly regenerating coastal scrub and forest. All the trees flower profusely in the spring (August to October) and two, which bear flowers with functional anthers and slender ovaries, have not set fruit. The other two trees, which bear flowers with aborted anthers and plump ovaries, are laden with fruit each autumn and the seeds germinate freely—there being a carpet of seedlings under both trees.

Over the same period I have watched the behavior of planted trees of *P. obcordatum* and *P. umbellatum* in the Auckland Domain, adjacent to the Museum where I work. The trees appear to be female (i.e. the flowers have apparently aborted anthers and plump ovaries, and fruit develop each year) but there are no "male" trees in the neighborhood. Possibly some of the anthers shed sufficient pollen to fertilize the ovaries, but this has not been observed.

Again I have received specimens of flowers and fruit from a plant of the Australian *P. undulatum*, planted in the grounds of the Middlemore Hospital, near Auckland. The flowers have plump ovaries and apparently aborted

⁸⁶ N.Z. Inst. Trans. & Proc. 4:260. 1872.

⁸⁷ N.Z. Inst. Trans. & Proc. 53:365. 1921.

⁸⁸ For. Fl. N.S.W. 7:124. 1920.

⁸⁹ N.Z. Inst. Trans. & Proc. 13:254. 1881, and 57:115. 1926.

⁹⁰ Personal communication.

anthers. The fruit are fully developed and the seeds germinate each year. There is no male plant of the species in the neighborhood, however, and the source of pollen is not known. More observations on all the Australian and New Zealand species of *Pittosporum* are required to determine the extent of dicliny.

Cufodontis⁹¹ stressed the value of the sepals as a criterion for the recognition of species and subspecies and described and illustrated five types of sepal arrangement. Only four of these types are found in the Australian and New Zealand species of *Pittosporum*: 1, sepals free or slightly coherent at base, not imbricate, e.g. *P. dallii*; 2, sepals free and clearly imbricate, e.g. *P. bicolor*; 3, sepals coherent, e.g. *P. melanospermum*; and 4, sepals connate in a tube splitting into 2 parts, one 1- to 2-lobed, the others 3- to 4-lobed, e.g. *P. undulatum*.

Occasionally in *P. phillyraeoides* and *P. cornifolium* one or two pairs of sepals are coherent from base to apex and the arrangement of the sepals varies slightly in most species examined. Size, shape, and pubescence of the sepals also vary, but are as valuable as sepal arrangement in the recognition of species.

The usual number of sepals and petals is five, but extra sepals and petals have been found rarely in *P. revolutum* and *P. phillyraeoides* (Australia), *P. erioloma* (Lord Howe Island), and *P. crassifolium* and *P. umbellatum* (New Zealand).

Petal color is constant in most of the Australian and New Zealand species of *Pittosporum* and is a useful character in the classification of the species. For about half of the species of the genus the flower color is not known, but in the remainder the colors usually found are white, greenish-white, and yellow. Red or purple flowers have been reported in three species in New Guinea, three species in New Caledonia, one species in the Tonga Islands, one species in Australia, and in most of the species in New Zealand. In the allied Australian genera there are a number of species with red, purple, and blue petals, and these colors seem to be associated strongly with small leaves, heterophylly, and reduced forms.

THE FRUIT:

Gowda⁹² recognized two major series in the Asiatic species which he termed the BIVALVAE and the TRIVALVAE, according to the carpel number. Cufodontis⁹³ did not discuss valve number but it is clear from his descriptions and illustrations that all the species he dealt with belong to the BIVALVAE. The character is somewhat variable, but the group to which a species belongs can be determined if sufficient fruits are available and cognizance is taken of associated characters.

Cufodontis⁹⁴ considered that valve shape is a valuable character and recognized four basic types based on cross-sections of the valves:

1. Valvae convexae—more or less evenly convex or with a flat middle portion.
2. Valvae concavae—between the convex edges lies a concave middle zone.
3. Valvae gibbosae—between the convex borders is a longitudinal dorsal thickening.
4. Valvae sulcatae—resembling 3, but with a longitudinal groove down the dorsal thickening.

⁹¹ Österr. Bot. Zeitschr. 98:109. 1951.

⁹² *loc. cit.* p.278. 1951.

⁹³ *loc. cit.* 1951.

⁹⁴ *loc. cit.* p.109. 1951.

As the four types represent the variation in cross-sections of two-valved fruits it was necessary to examine as many three-valved fruits as possible to determine whether the classification applied to these. Generally the four basic types are present in the TRIVALVAE but within some species more than one valve type is found. A rapid survey of the valve shape throughout the range of the genus gives the impression that the character is useful for the recognition of the Hawaiian species as a whole; the capsule valves of the Hawaiian species have a distinct longitudinal thickening with a median longitudinal groove. The character is also of value in the classification of species and subspecies.

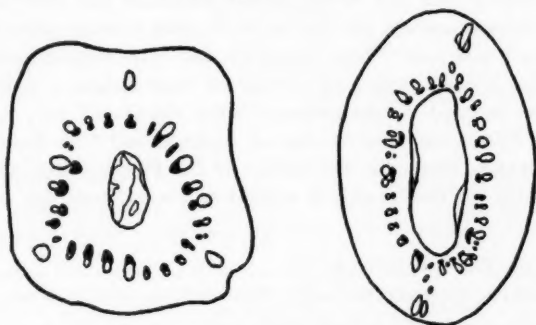


Fig. 4. Ovary sections of *P. crassifolium* (left) and *P. eugenoides* (right), New Zealand. Resin canals indicated by hollow circles; vascular strands indicated in black. $\times 23$.

Moore and Adams⁹⁵ described and figured a papery endocarp in the New Zealand *P. dallii*, *P. eugenoides*, and *P. anomalum*. Fruit of *P. crassifolium* and *P. eugenoides* both show (fig. 4) a more or less complete circle of large resin canals lying outside, rarely inside, the vascular supply which branches to all parts of the valve. In *P. eugenoides* the canals fuse more than they do in *P. crassifolium* and finally the endocarp, vascular supply, and mesocarp separate in the former species. Apart from the valve number and the resin canal development, no marked differences were found in the anatomy of the fruits of the two species. On boiling the fruits of *P. crassifolium* and *P. fairchildii*, I have found the endocarp partly or completely free from the vascular supply and mesocarp, and the separation of the tissues can be effected without difficulty in several species. No great significance can be placed on the presence or absence of a papery endocarp, although it is a useful character for the recognition of *P. dallii*, *P. eugenoides*, and *P. anomalum*. *Pittosporum dallii* and *P. eugenoides* may be related but there is nothing apart from this character to suggest a close relationship with *P. anomalum*; in fact all three are isolated and highly specialized members of the genus.

Gowda⁹⁶ used the placenta and funicles for the recognition of complexes of

⁹⁵ Trans. Roy. Soc. N.Z. 77: 250. 1949.

⁹⁶ loc. cit. 280. 1951.

East Asian species, and Cufodontis⁹⁷ has illustrated these characters for the African species. In the classification of the Australian and New Zealand species they are valuable, although in most species there is some variation in the length and thickness of the placenta and in the size and arrangement of the funicles. Emphasis is placed on the placenta and funicles as characters rather than the ovules, because the funicles persist whereas the ovules are frequently disarranged or missing on herbarium material.

GEOGRAPHY

The literature on the past history of the Australian and New Zealand flora and fauna is extensive and the conclusions of the most eminent authors frequently conflict. Raup⁹⁸ and Cain⁹⁹ have suggested that such varying points of view might be unified if plant geographers would use more inductive methods. With this good advice in mind, I have presented below the facts I have regarding the distribution of *Pittosporum* and its allies in Australia and New Zealand. I have included information about the distribution of the Pittosporaceae elsewhere as I am convinced that the family must be studied on a world basis, not on a regional one.

DISTRIBUTION OF THE PITTOSPORACEAE:

As at present understood the family Pittosporaceae comprises nine genera and about 276 species, the distribution of which is illustrated in fig. 5.

The species were defined originally by divers botanists, and it is improbable that they exercised taxonomic judgment to the same degree. A semblance of uniformity has been introduced by the general treatments of Pax¹⁰⁰ and Pritzel¹⁰¹, but further study will undoubtedly result in some of the species being relegated to synonymy and others being separated into new categories. Indonesia, New Guinea, and the Melanesian Islands will probably yield more forms when their floras are better known, and the revision of the Polynesian Island species will shed further light on the evolution of the family in the Pacific area.

From the figures available it is possible that the main centre of development is Australia (9 genera and 48 species) and that important secondary centres are the Hawaiian Islands (1 genus, 23 species), New Caledonia (1 genus, 46 species), New Zealand (1 genus, 20 species), southeast Asia (1 genus, 52 species), and Africa (1 genus, 10 species).

DISTRIBUTION OF HIGHER CATEGORIES:

Bentham¹⁰² Pax¹⁰³ and Pritzel¹⁰⁴ recognised two sub-families in the Pitto-

⁹⁷ Fedde's Rep. Sp. Nov. 55¹:27. 1952.

⁹⁸ Assoc. Amer. Geogr. Ann. 32:320. 1942.

⁹⁹ Foundations of Plant Geography. p. 210. 1944.

¹⁰⁰ Engl. & Prantl, Nat. Pflanzenfam. 3^{1a}:106. 1891.

¹⁰¹ Engl. & Prantl, Nat. Pflanzenfam. ed. 2. 18a:265. 1930.

¹⁰² In Benth. et Hook.f., Gen. Pl. 1:131. 1862.

¹⁰³ loc. cit. 1891.

¹⁰⁴ loc. cit. 1930.

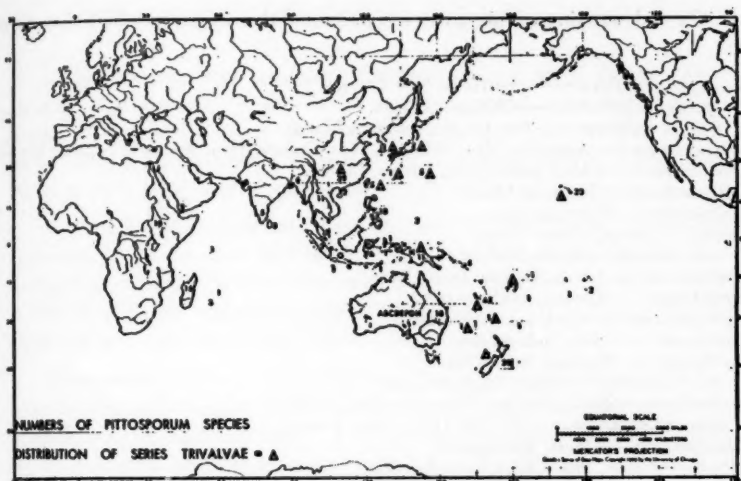


Fig. 5. World distribution of the Pittosporaceae. Figures indicate the number of *Pittosporum* species in that locality. Letters represent the following genera: A, *Billardiera* (8 species), B, *Bursaria* (2 species), C, *Cheiranthra* (4 species), D, *Marianthus* (16 species), E, *Pronaya* (1 species), F, *Sollya* (2 species), G, *Citriobatus* (4 species), H, *Hymenosporum* (1 species).

sporaceae, the PITTOSPOREAE, characterized by woody and leathery capsules, and the BILLARDIEAE, distinguished by succulent berries. In the PITTOSPOREAE, the genus *Pittosporum* is wide-ranging, *Hymenosporum* occurs in Australia and New Guinea; and *Marianthus*, *Cheiranthra* and *Bursaria* are known only from Australia. In the second subfamily, the BILLARDIEAE, the genus *Citriobatus* occurs in Australia, Java, Luzon, and the Celebes, while *Sollya*, *Billardiera* and *Pronaya* are known, so far, only from Australia. The regions where members of the two subfamilies have been found together are Australia, Java, Luzon, and the Celebes.

In the genus *Pittosporum*, the series BIVALVAE ranges from Hawaii to Africa and is present in all regions where the family is found, except the Ryu-kyu, Lord Howe, and Norfolk islands. The series TRIVALVAE is known from the mainland of China, Formosa, the Ryu-kyu and Bonin islands, Japan, South Korea, New Guinea, New Zealand, Lord Howe and Norfolk islands, Fiji, and Hawaii. The regions where members of the two series of *Pittosporum* have been found together are Upper Burma and Assam, western and southwestern China, Formosa, the Bonin Islands, New Guinea, New Zealand, Fiji, and Hawaii.

I do not know of any region where both subfamilies of the Pittosporaceae and both series of *Pittosporum* occur.

DISTRIBUTION OF WIDE-RANGING SPECIES:

The wide-ranging members of the family and the regions in which they occur are:

- Hymenosporum flavum*—Australia, New Guinea.
Pittosporum ramiflorum—Philippines, Java.
 var. *parviflorum*—New Guinea, Solomon Islands.
P. ferrugineum—Australia, New Hebrides, New Guinea, Java, Sumatra, Nicobar Islands.
P. podocarpus—China, Indo-China, Burma, India.
P. oligocarpum—Formosa, China.
P. sabnianum—Formosa, China.
P. tobira—Japan, Korea, China.
 var. *sukurai*—Bonin Islands.
P. baileyianum—China, Hainan, Indo-China.
P. ceylanicum—Ceylon, southern India.
P. neelgherrense—Ceylon, southern India.
P. nervosum—China, Indo-China.
P. formosum—Formosa, Indo-China.
 var. *bainanense*—Indo-China, Hainan.
P. napaulense—Nepal, Sikkim, Tibet, Bhotan, Assam.
 var. *rawalpindiense*—Sikkim, Dehra Dun, Punjab.
P. floribundum—India, Madagascar.
P. kerrii—China, Indo-China, Siam, Burma.
P. johnstonianum—China, northern Burma.
P. tetraspermum—China, India.
P. viridiflorum—Arabia (Yemen), Ethiopia, central and southern Africa.

Gowda¹⁰⁵ considered *Pittosporum ferrugineum* to be an extremely variable and poorly understood species, but I have found it too coherent to allow separation of the Australian, New Guinean, and Indonesian forms with the material available. At present it is the only species of *Pittosporum* known which extends from Australia to Asia but it does not reach the Asiatic mainland. Gowda¹⁰⁶ found that none of the eastern Asiatic species of *Pittosporum* occurred in Indonesia, New Guinea, or Australia, but Li¹⁰⁷ believed that Gowda was mistaken and that some species extend from Asia to Indonesia.

I am tempted to speculate on the past land connections indicated by some of these ranges, but it is possible that diaspores of the species have been carried to their present areas by birds, hurricanes, and ocean currents. I must emphasize, too, the probability that these populations will undergo further revision in the future.

DISTRIBUTION OF INTERGRADING SPECIES:

The species of *Pittosporum* found in Hawaii are evidently very closely related. Sherff¹⁰⁸ wrote:

Much of the trouble in making a workable key for Hawaiian *Pittospora* lies in the fact that numerous subspecific entities, namely varieties and forms

¹⁰⁵ Jour. Arnold Arb. 32: 322. 1951.

¹⁰⁶ loc. cit. 1951.

¹⁰⁷ Jour. Wash. Acad. Sci. 43:43. 1953.

¹⁰⁸ Field Mus. Nat. Hist. Bot. Ser. 22:472. 1942.

(formae), occur. While these have their individual criteria by which they usually can be recognized, they nevertheless afford so many intermediate characters as to make their respective species seem to intergrade or even overlap.

Similar remarks have been made regarding the species of *Pittosporum* which occur in New Zealand. J. D. Hooker has been quoted previously; Kirk¹⁰⁰ commented of *P. tenuifolium*, *P. colensoi*, and *P. fasciculatum*: "These forms vary considerably in all their parts, so that it would not be difficult to obtain a connected series of specimens which should include the whole."

In the taxonomic treatment I have discussed *P. ellipticum* var. *decorum*, which appears to be intermediate between *P. ellipticum*, *P. buttonianum* and *P. ralphii* and have mentioned *P. intermedium*, which resembles large forms of *P. tenuifolium* in foliage, while the capsule partakes of the characters of *P. crassifolium* and the sepals and petals match *P. umbellatum* in size and shape.

Pittosporum rigidum, *P. divaricatum*, *P. crassicaule*, and *P. anomalum* contain a bewildering series of polymorphic and heterophyllous forms most of which occur in small areas at high elevations. Another series of intergrading forms occurs in North Auckland, and has been variously treated by different authors; I suspect that *P. reflexum* and *P. pimeleoides* are sun and shade forms of the same species but have seen too few living specimens to be certain. The large linear-leaved forms of *P. pimeleoides* resemble juvenile plants of *P. virgatum*, and some of the adult plants of *P. virgatum* are very similar to juvenile plants of *P. umbellatum*.

The problem of intergrading forms in the Australian species of *Pittosporum* is slight. Small-leaved forms of *P. undulatum* have been misidentified as glabrous forms of *P. bicolor* and some are close to small-leaved specimens of *P. revolutum*, but generally the species are easily recognised by their morphological characters.

Gowda¹¹⁰ indicated a number of closely allied species of *Pittosporum* in eastern Asia, the most noteworthy being *P. kerrii* (Siam, China), *P. floribundum* (southern India, Madagascar), and *P. ripicola* (central and eastern Africa). Three groups of intergrading species are mentioned: (1) *P. napaulense*, *P. floribundum*, and *P. kerrii*; (2) *P. truncatum* and *P. heterophyllum*; and (3) *P. trigonocarpum* and *P. sabnianum*.

I have been unable to determine the frequency of intergrading forms in the species of *Pittosporum* described from other areas, and any conclusions are premature. So far the evidence indicates that intergrading forms are more frequent in the Hawaiian Islands and New Zealand than in Australia and Asia. Gowda¹¹¹ recognised 52 species of *Pittosporum* in southeastern Asia, and the intergrading species amount to about a seventh of the total. The proportion of intergrading species in the New Zealand and Hawaiian species is much higher.

¹⁰⁰ N.Z. Inst. Trans. & Proc. 4:262. 1872.

¹¹⁰ Jour. Arnold Arb. 32:284. 1951.

¹¹¹ loc. cit. 1951.

DISTRIBUTION OF ENDEMIC SPECIES IN AUSTRALIA AND NEW ZEALAND:

All species of *Pittosporum* in New Zealand are endemic, but only *P. tenuifolium* and *P. eugenioides* are found throughout the country. The other New Zealand members of the TRIVALVAE and BIVALVAE occupy smaller areas. For example, *P. turneri* is known only from one locality on the Central Volcanic Plateau of the North Island, and a closely allied species, *P. patulum*, occurs in a few localities in the mountains of northwest Nelson, in the South Island. *Pittosporum fairchildii* is restricted to the Three Kings Islands, a group of rocks some 30 miles off the coast, and *P. dallii* is known only from one locality where about a dozen plants have been found. A number of the ranges of the New Zealand species are disjunct and most of the small-leaved heterophyllous species have been found in small isolated populations. For example, *P. obcordatum* is known only from three isolated localities several hundred miles apart, the total population being about 15 trees.

All Australian species of *Pittosporum* are endemic, except *P. ferrugineum* which is also found in the New Hebrides, New Guinea, and Indonesia. *Pittosporum bracteolatum* is restricted to Norfolk Island and *P. erioloma* is known only from Lord Howe Island. *Pittosporum bicolor* is most common in Tasmania, but occurs in Victoria and New South Wales. An allied species, *P. phillyraeoides*, is found in every state, except Tasmania. The most widespread of the remaining species is *P. revolutum*, which extends from Queensland to Victoria, a distance of 1000 miles. Within this range are the areas of *P. rhombifolium*, *P. rubiginosum*, *P. undulatum*, and *P. o'reillyanum*. *Pittosporum venulosum* is found on the coast of Queensland farther to the north, and *P. melanospermum* has been collected from the same coast and from the Northern Territory. No one species occupies the whole of the Australian continent, but the majority of species occupy relatively large areas; and all have continuous ranges, except possibly *P. melanospermum*. Furthermore, if the populations of Norfolk and Lord Howe islands are excluded from the Australian species, the number of individuals comprising an Australian species is far greater than the number of a New Zealand population.

CLIMATE:

The climatic regions of Australia and New Zealand, according to Thornthwaite's classification¹¹², and the number of species of *Pittosporum* in each are plotted in fig. 6. The species of *Pittosporum* in the twelve climatic areas are listed below, each species being indicated by its number in the present taxonomic treatment.

The concentration of *Pittosporum* species in eastern Australia (Queensland, New South Wales, and Victoria) and the relative paucity of species in central and western Australia, specifically the desert and steppe climate areas, is noteworthy. *Pittosporum phillyraeoides*, the only species which is found throughout southern, central, and western Australia, is xeromorphic as are some of the species of the

¹¹² Geog. Rev. 28: 433. 1933.

Climatic type*	Australian Species	Norfolk and Lord Howe Islands	New Zealand Species
A A'r	24, 25, 27, 30		
B A'w	24, 25, 27, 28, 29, 30		
B B'r	9, 10, 24, 26	1, 2	3, 4, 5, 6, 7, 8, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 31, 32
C A'w	9, 28		
C B'd	9, 11, 24, 26, 29		
C B'r	9, 10, 24, 26		
C B's	9		
D A'w	9		
D B'd	9		
D B's	9		
E A'd	9 (coastal only)		
E B'd	9 (coastal only)		

* The first letter of the climate type indicates the vegetation transitions due to diminished effective rainfall: (A) rain forest, (B) forest, (C) grassland, (D) steppe, and (E) desert. The second letter indicates the vegetation transitions due to diminished temperature efficiency: (A') tropical rain forest, and (B') temperate rain forest. The third letter indicates the seasonal distribution of precipitation: (r) precipitation at all seasons, (s) scanty rainfall in summer, abundant in winter, (w) scanty rainfall in winter, abundant in summer, and (d) dry at all seasons.

allied genera which occur in the desert and steppe. The development of the allied genera mainly in the southern parts of Australia is linked with the development of the so-called Australian elements in the flora and arid periods in the Post-Pleistocene.¹¹³ Stebbins¹¹⁴ has presented evidence in favour of a hypothesis that environments limiting or deficient in one all-important factor, moisture, often have promoted rapid evolution. The variety of life-forms in the allied genera is strikingly different from the general uniformity of *Pittosporum* and may be the result of evolution under the stimulus of aridity. The northerly concentration of the New Zealand species is illustrated by grouping the species according to the two major geographical units. Until the close of the Pliocene period Cook Strait, which separates the North and South Islands, was closed and there was no barrier to the spread of species north and south.

Species found in the North Island only 11

Species found in the South Island only 2

Species common to both islands 7

20

Owing to its relatively small size, New Zealand has only one climatic type,

¹¹³ Crocker and Wood, in Trans. Roy. Soc. S. Austr. 71:91. 1947.

¹¹⁴ Amer. Nat. 86:33. 1952.

but generally the North Island has warmer summers and milder winters than the South Island. Zotov¹¹⁵ studied the correlation between vegetation and climate in New Zealand and commented:

On the continents where annual variation of temperature is great, the absolute minimum value of temperature—i.e. degrees of frost—may become a very important limiting factor for the distribution of many species. In New Zealand, however, the minimum temperature does not appear to be of importance for the great majority of species, since they reach their summer "limiting temperature" in places well outside the boundaries of limiting winter temperature.

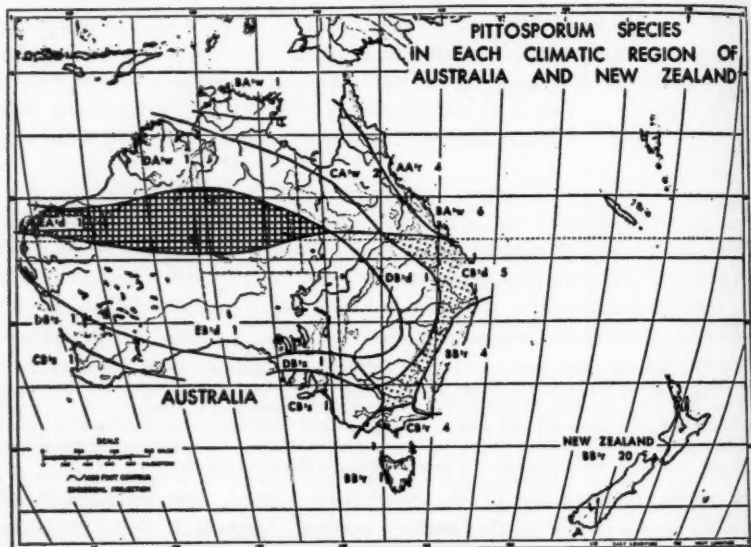


Fig. 6. Number of species of *Pittosporum* in each climatic region of Australia and New Zealand. For explanation see text and table on preceding page.

On Thornthwaite's¹¹⁶ maps of climatic types the regions occupied by the species of *Pittosporum* outside Australia and New Zealand are generally in the rain forest, forest, or grassland classes, for effective rainfall, and in the tropical and temperate rain forest classes, for temperate efficiency. Over much of the range of the genus the isothermal difference between extreme months is relatively small.

In the Pittosporaceae the largest plants are *Pittosporum brackenridgii* of Fiji (tree to 25 m. tall), *P. undulatum* of Queensland, Australia (tree to 30 m. tall), and *P. viridiflorum* of Africa (tree to 25 m. tall). These species occur in tropical rain forests. The smallest plants are those of *Marianthus procumbens* of Australia (a low shrub to 30 cm. tall) and its allies, *Pittosporum anomalum* of New Zealand (semi-prostrate shrub to 1 m. tall) and its allies, and *P. saxicola* of Western Szechwan (prostrate shrub 0.3 - 2.0 m. tall) and its allies. These species are found in

¹¹⁵ N.Z. Jour. Sci. Tech. 19: 474. 1938.

¹¹⁶ loc. cit. 1933.

various habitats at the extreme northern and southern boundaries of the family and are dwarfed in all organs.

In the evolution of these forms low temperatures may have been significant, but it is also possible that aridity has played a role. For example, the small-leaved xeromorphic *P. pimeleoides* is found on strongly leached podzolized and skeletal soils where *Agathis australis* grows or formerly grew, and the small-leaved xeromorphic *P. divaricatum*, *P. rigidum*, *P. crassicaule*, and *P. anomalum* occur on skeletal mountain and volcanic soils.

GEOLOGICAL HISTORY:

The literature on past land connections of Australia and New Zealand is large (Benson¹¹⁷, David^{118, 119}, Marwick¹²⁰, Merrill¹²¹, Oliver¹²², Skottsberg¹²³), and the diastrophic paleontologic, faunal, and floristic evidence is substantial. It is generally accepted that there have been no land connections between Australia and Asia in Tertiary and recent times (David¹²⁴, Diels¹²⁵, Merrill¹²⁶), and it is usually implied or stated that the present land area of the Australian continent has remained above water throughout Tertiary and Recent periods, save for temporary marginal incursions. The scanty relics of Upper Cretaceous floras are sufficient to show that flowering plants were established on the Australian land area prior to the Tertiary, and studies of more recent floras indicate that the flowering plants experienced significant climatic modifications in the post-Tertiary.¹²⁷

I can find no reference to fossil forms of the Pittosporaceae in Australian paleobotanical papers. Cookson and Couper¹²⁸ informed me that pollens of the Pittosporaceae are not used as indicators in Australian and New Zealand Tertiary pollen studies, and that their absence from published species lists has no significance. The well-marked morphological characters of the Australian species and the large geographical areas of most of the populations indicate that the group has evolved in isolation over a comparatively long period. I suggest that these morphological and geographical characteristics are indicative, and perhaps typical, of evolution under continental conditions.

In a recent discussion of the geological history of New Zealand with reference to the origin and history of the fauna and flora, Fleming¹²⁹ emphasized that the New Zealand area has long been a relatively isolated archipelago of islands. He

¹¹⁷ Gedenboek, Dr. R.D.M. Verboek, etc. p.53. 1925.

¹¹⁸ Geology of the Commonwealth of Australia. 3 vols. 1950.

¹¹⁹ Tuatara 2:72. 1949.

¹²⁰ N.Z. Jour. Sci. & Tech. 11: 202. 1929.

¹²¹ Far Eastern Quart. 2:66. 1942.

¹²² Jour. Linn. Soc. Lond. Bot. 47: 99. 1925.

¹²³ Plant World 18:129. 1915.

¹²⁴ loc. cit. chap. 15. 1950.

¹²⁵ Essays on Geobotany in honor of W. A. Setchell. p.194. 1936.

¹²⁶ loc. cit. 1942.

¹²⁷ David, loc. cit. p. 650. 1950; Gill, in Austral. Jour. Sci. 15: 47. 1952; Crocker and Wood, in Trans. Roy Soc. S. Austr. 71:91. 1947.

¹²⁸ Personal communications.

¹²⁹ Tuatara 2:72. 1949.

pointed out that the frequent changes in the size and relations of the islands may have played a significant role in the formation of races species of plants and animals. Marked climatic changes since the Cretaceous epoch are indicated by faunal changes in the fossil record¹³⁰, and several post-glacial, climatic fluctuations are reflected in the sequence of pollens found by Von Post and Cranwell¹³¹ in peat deposits and in profiles of soils studied by Raeside¹³².

Arber¹³³ found two dicotyledons in rocks of Jurassic or lower Cretaceous age, and Couper¹³⁴ found Angiosperm pollens in coals of early Cretaceous-Eocene age. *Pittosporum* leaves have been found in beds of lower Oligocene, lower Miocene and upper Pliocene age by Oliver¹³⁵, and in beds of upper Pliocene or lower Pleistocene age by McQueen¹³⁶.

In the discussion of the distribution pattern of New Zealand species of *Pittosporum* it was noted that endemism is high, intergrading forms are common, and geographic ranges are small. Apparently these characteristics are the result of a long period of evolution in a changing and relatively isolated archipelago under fluctuating climatic conditions, and I suspect that they are typical of most species formed under insular conditions. It is possible, of course, that the differences noted between the species of *Pittosporum* occurring in Australia and those found in New Zealand are due mainly to the continental outlook of Australian taxonomists and the more insular attitude of New Zealand botanists!

In a discussion of the floras of Madagascar and New Caledonia, Good¹³⁷ observed that the relative situations of the two groups of islands to the continents of Africa and Australia respectively are very similar, that the physiographic structure of the main islands is curiously alike, that the climatic types correspond, and that both possess floras with a large number of endemic species. Twenty Old World (African-Asiatic-Australian) genera have complexes of endemic species in Madagascar and New Caledonia, and Good cited *Pittosporum* as the most interesting of them, a citation which I heartily endorse. He suggested, however, that these curious similarities are the result of past land movements, or continental drift, and this I must question. If the distribution of the genus *Pittosporum* is used as evidence, the range of all species should be considered. Lists of closely allied species given previously link the various centers of development of the genus and suggest that extensive movements of the land horizontally are not required to explain the present distribution of the genus in Madagascar and New Caledonia.

¹³⁰ Fleming, in Tuatara, loc. cit. 1949.

¹³¹ Geograf. Ann. Hef. 3-4: 308. 1936.

¹³² Trans. Roy. Soc. N.Z. 77: 153. 1948.

¹³³ N.Z. Geol. Surv. Pal. Bull. 6. 1917. McQueen (Nature 175:177. 1955) said that the slab studied by Arber came from Upper Cretaceous beds and that the earliest New Zealand angiosperms are Cretaceous in age.

¹³⁴ N.Z. Sci. Rev. 9: 5. 1951, and N.Z. Geol. Surv. Pal. Bull. 22 (in press).

¹³⁵ N.Z. Inst. Trans. & Proc. 23: 276. 1891; and 59: 287. 1928; Tuatara 3: and 1 and 8, 1950.

¹³⁶ Personal communication.

¹³⁷ Blumea 6: 470. 1950.

Chevalier¹³⁸ considered *Pittosporum* to be a South Oceanic genus and remarked:

... le grande foyer de dispersion du genre *Pittosporum* ce sont l'Australie et les îles du Pacifique. Du reste, sur 10 genres que compte la famille des Pittosporées, 8 sont endémiques en Australie, le genre *Pittosporum* est aussi en grande partie pacifico-australien, le dixième genre *Tribeles* phil. (= *Chalepou* Hook. f.) avec une unique espèce *Tribeles australis* Philippi (= *Chalepou antarctica* Hook. f.) est confiné à la partie extrême Sud de l'Amérique (sud du Chili jusqu'à l'île Chilôé, Patagonie et île Clarence). Il semble donc que les *Pittosporum* ont essaimé des terres australes vers l'Asie, d'une part, et vers l'Afrique, d'autre part; une seule Pittosporée est parvenue en Amérique australe, à sa pointe extrême.

Engler¹³⁹ placed *Tribeles* in the subfamily ESCALLONIOIDEAE of the Saxifragaceae, however, and while that family may be related to the Pittosporaceae, there is no certain evidence that the Pittosporaceae are represented in South America. Furthermore, the development of the Pittosporaceae in Australia and New Zealand is not evidence that the family originated in that part of the world. The determination of the center of origin for the family must await the progress of paleobotany, cytology, and possibly plant exploration. For example, further field work in the New Guinea-New Caledonia area is likely to yield further novelties and throw new light on the distribution of the Pittosporaceae.

INTERRELATIONS OF THE SPECIES

Methods by which a pictorialized scatter diagram is developed are explained in Anderson^{140, 141} and Anderson and Gage¹⁴². The figures listed in Table I are the maximum measurements made of capsule width and the averages of the measurements made of petal length, sepal length and petal width for the taxonomic treatment. The averages are the means of the actual measurements made on the herbarium material cited in the text.

The measurements have been plotted as a pictorialized scatter diagram (fig. 7), to facilitate an understanding of the relationships of the species and subspecies of *Pittosporum*. Petal width and capsule width were chosen as abscissa and ordinate respectively because they varied consistently within each species and could be measured accurately. The other three characters were indicated by rays from each dot on the diagram. The number alongside each dot refers to the species in the taxonomic treatment. Limits of the three grades of each character were chosen so that extremes associated with higher values for petal width and capsule width are indicated by long rays and extremes associated with lower values for petal width and capsule width are represented without rays.

¹³⁸ Bull. Soc. Bot. Fr. 93: 205. 1946.

¹³⁹ Engl. & Prantl's, Nat. Pflanzenfam. ed. 2. 18a: 213. 1930.

¹⁴⁰ Introgressive hybridization. 1949.

¹⁴¹ Plants, Man and Life. 1952.

¹⁴² Amer. Jour. Bot. 39: 399. 1952.

At one extreme, the upper right-hand corner of each diagram, are the species with petals and sepals which are markedly long and capsules which are three-valved and markedly broad. In the New Zealand diagram most of the species at this extreme are in the series TRIVALVAE. In the Australian diagram the species numbered 1 and 2 (*P. bracteolatum* of Norfolk Island and *P. erioloma* of Lord Howe Island) are in the TRIVALVAE; the other species of this extreme are in the BIVALVAE, but approach the TRIVALVAE closely.

At the other extreme, the lower left-hand corner of the diagram, are the species with petals and sepals which are markedly short and capsules which are two-valved and markedly narrow. In the New Zealand diagram most of the species at this extreme are small-leaved, dwarf members of the BIVALVAE with small fascicles or solitary flowers. In the Australian diagram most of the species at this extreme are large-leaved tall members of the BIVALVAE with spreading compound inflorescences. Species numbered 12, 15, 13, 16, and 14 on the New Zealand diagram (*P. umbellatum*, *P. patulum*, *P. virgatum*, *P. turneri* and *P. pimeleoides* respectively) show a proportionate reduction in all characters illustrated, from the upper right-hand extreme to the lower left-hand extreme, and may connect the series TRIVALVAE and the small-leaved dwarf members of the BIVALVAE. The variety of leaf-forms in these five species has been illustrated previously and the suggestion has been made that the leaf forms indicate the direction of evolution in the New Zealand species.

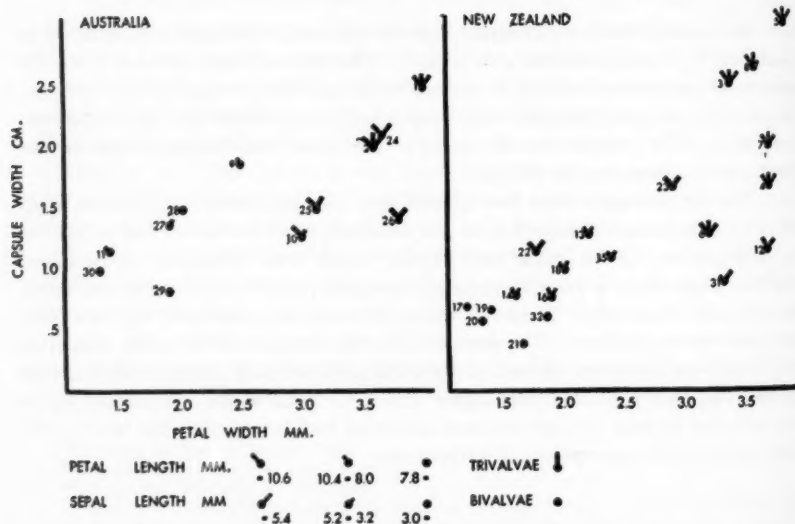


Fig. 7. Pictorialized scatter diagram of information contained in Table I, showing relationships of 32 species of *Pittosporum* as indicated by capsule width and by measurements of petals and sepals. Horizontal axis, petal width; vertical axis, capsule width. Petal length and sepal length are diagrammed by rays as explained on the diagram. Numbers beside dots refer to the position of the species in the taxonomic treatment.

TABLE I
AVERAGE MEASUREMENTS OF THE AUSTRALIAN AND NEW ZEALAND
SPECIES OF *PITTOSPORUM*

Species	Petal length mm.	Petal width mm.	Sepal length mm.	Valve number	Capsule width cm.
1. <i>P. bracteolatum</i>	17.0	4.0	10.7	3	2.5
2. <i>P. erioloma</i>	16.0	3.6	6.2	3	2.0
3. <i>P. fairchildii</i>	11.8	3.4	5.6	3	2.5
4. <i>P. ellipticum</i>	15.3	3.7	9.3	3	1.7
5. <i>P. crassifolium</i>	13.6	3.9	9.3	3	3.0
6. <i>P. ralphii</i>	14.8	3.2	8.7	3	1.3
7. <i>P. buttonianum</i>	15.6	3.7	7.1	3	2.0
8. <i>P. tenuifolium</i>					
ssp. <i>tenuifolium</i>	10.8	3.6	4.5	3	2.6
ssp. <i>colensoi</i>					
9. <i>P. phillyraeoides</i>	10.1	2.5	2.6	2	1.9
10. <i>P. bicolor</i>	11.2	3.0	4.2	2	1.3
11. <i>P. o'reillyanum</i>	9.2	1.4	1.9	2	1.2
12. <i>P. umbellatum</i>	11.5	3.7	7.1	2	1.2
13. <i>P. virgatum</i>	10.0	2.2	4.6	2	1.3
14. <i>P. pimeleoides</i>					
ssp. <i>pimeleoides</i>	9.7	1.6	4.0	2	.8
ssp. <i>major</i>					
15. <i>P. patulum</i>	10.0	2.4	4.9	2	1.1
16. <i>P. turneri</i>	8.1	1.9	4.0	2	.8
17. <i>P. obcordatum</i>	5.8	1.2	2.1	2	.7
18. <i>P. rigidum</i>	9.8	2.0	3.9	2	1.0
19. <i>P. crassicaule</i>	5.4	1.4	1.5	2	.7
20. <i>P. divaricatum</i>	5.2	1.3	1.9	2	.6
21. <i>P. anomalum</i>	3.4	1.7	1.9	2	.4
22. <i>P. cornifolium</i>	11.1	1.8	5.7	2	1.2
23. <i>P. kirkii</i>	17.6	2.9	8.6	2	1.7
24. <i>P. revolutum</i>	15.1	3.7	6.0	2	2.1
25. <i>P. rubiginosum</i>					
ssp. <i>rubiginosum</i>	13.0	3.1	6.8	2	1.5
ssp. <i>wingii</i>					
26. <i>P. undulatum</i>	13.7	3.8	7.9	2	1.4
27. <i>P. venulosum</i>	7.9	1.9	4.1	2	1.4
28. <i>P. melanospermum</i>	7.6	2.0	1.7	2	1.5
29. <i>P. rhombifolium</i>	6.3	1.9	1.6	2	.8
30. <i>P. ferrugineum</i>	7.5	1.3	2.9	2	1.0
31. <i>P. dallii</i>	8.7	3.3	5.7	2	.9
32. <i>P. eugeniioides</i>	6.2	1.8	2.3	2	.6

Species numbered 22 and 23 (*P. kirkii* and *P. cornifolium*) are rather isolated, very similar in their rays, and are both epiphytic. Species numbered 31, 32 and 21, (*P. dallii*, *P. eugeniioides* and *P. anomalum*), are somewhat isolated and are the three species in which capsules with a persistent papery endocarp are found.

In the Australian diagram, species numbered 10, 9, and 11 (*P. bicolor*, *P. phillyraeoides*, and *P. o'reillyanum*) show a similar proportionate reduction to that noted for the New Zealand *P. umbellatum* - *P. pimeleoides* group. The remaining Australian species fall into two groups. The first group is characterized by petals and sepals which are long and broad. Associated characters are few flowers and lobed, ellipsoid or ovoid capsules. The second group is characterized by petals and

sepals which are small and narrow. Associated characters are very numerous flowers and usually smaller globose or obovoid capsules.

Group 1

- 24. *P. revolutum*
- 25. *P. rubiginosum*
- 26. *P. undulatum*

Group 2

- 27. *P. venulosum*
- 28. *P. melanospermum*
- 29. *P. rhombifolium*
- 30. *P. ferrugineum*

Many years ago, Bentham¹⁴³ recognized that *P. revolutum*, *P. rubiginosum* and *P. undulatum* had characters in common, and that *P. rhombifolium*, *P. melanospermum* and *P. ferrugineum* had some general affinity, but, apart from his key and arrangement of species, he did not express his views on the relationship of the species.

The significance of the pictorialized scatter diagram is that it shows a high degree of correlation among the characters employed, and strongly supports the key and taxonomic arrangement. Moreover, since the diagram is based on actual measurements, the results expressed therein are repeatable.

STUDY MATERIALS

Specimens from the herbaria of the following institutions have been studied, and the symbols¹⁴⁴ employed in their citation are indicated.

- A —Arnold Arboretum of Harvard University, Cambridge, Mass.
- AK —Auckland Institute and Museum, Auckland, New Zealand.
- BH —Bailey Hortorium, Cornell University, Ithaca, N.Y.
- BISH —Bernice P. Bishop Museum, Honolulu, Hawaii.
- BM —British Museum (Natural History), London, England.
- BRI —Department of Agriculture, Brisbane, Australia.
- CANB —Division of Plant Industry, CSIRO, Canberra, Australia.
- CANTY —Canterbury Museum, Christchurch, New Zealand.
- CU —Wiegand Herbarium, Cornell University, Ithaca, N.Y.
- F —Chicago Natural History Museum, Chicago, Ill.
- GH —Gray Herbarium of Harvard University, Cambridge, Mass.
- HO —University of Tasmania, Hobart, Tasmania.
- ILL —Department of Botany, University of Illinois, Urbana, Ill.
- K —Royal Botanic Gardens, Kew, England.
- MASS —Department of Botany, University of Massachusetts, Amherst, Mass.
- MEL —National Herbarium of Victoria, Melbourne, Australia.
- MO —Missouri Botanical Garden, St. Louis, Mo.
- NSW —National Herbarium of New South Wales, Sydney, Australia.
- P —Muséum National d'Histoire Naturelle, Laboratoire de Phanérogamie, Paris.
- U —Botanical Museum and Herbarium, State University of Utrecht, Netherlands.
- UMEL —Department of Botany, University of Melbourne, Melbourne, Australia.
- US —Department of Botany, U. S. National Museum, Washington 25, D. C.
- W —Naturhistorisches Museum, Wien, Austria.

¹⁴³ Fl. Austr. 1: 110. 1863.

¹⁴⁴ Lanjouw & Stafleu, Reg. Veg. Index Herbariorum Pt. 1. The herbaria of the world, ed. 2. 1954.

ACKNOWLEDGMENTS

I wish to acknowledge my indebtedness to the curators of the herbaria listed above for the loan of specimens and other courtesies. The Director and staff of the Auckland Museum, and many Australian and New Zealand friends, have supplied me with specimens and information. I am also indebted to Dr. Egbert Walker of the U.S. National Museum and to Dr. F. Raymond Fosberg of the U.S. Geological Survey for sponsoring my visit to the United States, and to the Director and staff of the Missouri Botanical Garden, and to the Dean and staff of the Henry Shaw School of Botany, for many kindnesses during my stay. Finally, I must express my great obligation to Dr. Robert E. Woodson, Jr., of the Missouri Botanical Garden, who made my visit to the United States possible and for whose assistance and advice I cannot be sufficiently grateful.

TAXONOMY

PITTOSPORUM Banks & Soland. ex Gaertn. Fruct. et Sem. 1: 286. *t.* 59. 1787-88 (T.: *P. tenuifolium*). Banks & Soland.

Pittosporoides Banks & Soland. ex Gaertn. Fruct. et Sem. 1: 286. 1787-88, *nom. nud.* in *synon.*

Erect trees or shrubs, rarely prostrate or epiphytic, pubescent or glabrous, unarmed or spinose. Leaves alternate, occasionally subverticillate, usually entire, petiolate, rarely sessile. Inflorescence terminal, terminal and lateral, or axillary, few to many-flowered, in fascicles or in umbelliform to paniculiform cymes, or solitary. Sepals 5, free, coherent or rarely connate. Petals 5, free or connivent, tips spreading or recurved. Stamens 5, erect; anthers 2-celled, introrse. Ovary sessile or stipitate, incompletely 2- to 4-celled; stigma capitate to truncate; style usually short. Capsule globose, ovoid, or obovoid, 1-celled; valves 2 - 5, woody or coriaceous, with a median longitudinal parietal placenta. Seeds immersed in a resinous viscid fluid.

The synonymy of *Pittosporum* is given in full by Pritzel¹⁴⁵.

KEY TO THE SERIES

- Capsules 3-valved, rarely 4- or 2-valved; seeds many; sepals and petals relatively large; sepals pubescent (puberulent to glabrous in *P. tenuifolium*). Norfolk Island, Lord Howe Island, and New Zealand. I. TRIVALVAE
 Capsules 2-valved, rarely 3-valved; seeds few; sepals and petals relatively small; sepals minutely puberulent or glabrous (pubescent in *P. rubiginosum*, *P. venulosum* and *P. virgatum*). Australia and New Zealand II. BIVALVAE

¹⁴⁵ Engler & Prantl, Nat. Pflanzenfam. ed. 2. 18a:273. 1930.

SERIES I. TRIVALVAE

SERIES I. TRIVALVAE Gowda, in Jour. Arnold Arb. 32:284. 1951.

KEY TO THE SPECIES

- a. Petals cream-white or yellow-green; sepals glabrous or scantily pubescent without; flowers terminal, 1-8, fascicled; capsules globose to pyriform; valves usually convex in transverse section with a placenta bearing funicles from the base to the apex. Norfolk and Lord Howe Islands.
 - b. Trees to 7 m. tall; leaves acuminate, 5-11 cm. long, 2.0-3.6 cm. broad; sepals linear, acuminate, 10.0-13.5 mm. long, 2.5-3.0 mm. broad, with a few hairs on the main vein without, glabrous within; petals yellow-green; capsules globose to pyriform, 2.0-3.5 cm. long, 1.5-2.5 cm. broad, without persistent dried sepals. Norfolk Island1. *P. bracteolatum*
 - bb. Shrubs to 5 m. tall; leaves acute, 3-5 cm. long, 1.0-1.8 cm. broad; sepals lanceolate, acute, 4-8 mm. long, 1.5-2.5 mm. broad, glabrous without, brown-tomentose within; petals cream-white with a reddish claw; capsules usually globose, 1.3-2.0 cm. in diameter, often with persistent dried sepals. Lord Howe Island2. *P. erioloma*
- aa. Petals purple, reddish-brown, or red; sepals pubescent without (scantly puberulent to glabrous in *P. tenuifolium*); flowers terminal or axillary, 1-10, fascicled or solitary; capsules subglobose or trigonous, rarely 2- or 4-lobed; valves convex to concave in transverse section with a placenta bearing funicles from the base to about the middle (to the apex in *P. fairchildii*). New Zealand
 - b. Flowers in terminal fascicles of 2-10, rarely solitary; capsules relatively large and thick.
 - c. Capsules subglobose; valves convex in transverse section, 1.5-2.0 mm. thick at margins; flowers up to 6 per fascicle; petals purple, reddish-brown, or chocolate.
 - d. Shrubs 3-5 m. tall; flowers 2-4; sepals lanceolate, acute, 4-7 mm. long, brown-tomentose without, glabrous within; petals purple; capsules 3-valved; valves not markedly thickened at apex, bearing minute funicles from the base to the apex; seeds black, round. Three Kings Islands3. *P. fairchildii*
 - dd. Trees to 8 m. tall; flowers 2-6; sepals linear, acuminate, 8-11 mm. long, rusty-tomentose without and to near the base within; petals reddish-brown to chocolate; capsules 3- or 2-valved; valves much thickened at apex, bearing flattened funicles up to 1 mm. long from the base to the middle; seeds reddish-black, irregular. North Auckland, Auckland, Thames and East Cape4. *P. ellipticum*
 - cc. Capsules trigonous, rarely 2- or 4-lobed; valves concave in transverse section, 2-3 mm. thick at margins; flowers up to 10 per fascicle; petals dark red to purple.
 - d. Shrubs to small trees 1-10 m. tall; leaves obovate to oblanceolate, 3-8 cm. long, 1-3 cm. broad, attenuate at base, with strongly thickened and revolute margins, secondary veins about 5 per side; flowers 1-10; sepals oblong to linear-lanceolate, acute, brown-tomentose without and above the middle within; capsules 1-3 cm. long and broad; valves 2-3 mm. thick, woody, with a placenta bearing conspicuous funicles. North Auckland, Auckland, and Thames, on the coast. Kermadec Islands5. *P. crassifolium*
 - dd. Shrubs 2.5-4.0 m. tall; leaves oblong to obovate, 4-12 cm. long, 2-4 cm. broad, acute to obtuse at base, with unthickened flat or revolute margins, secondary veins 9-12 per side; flowers 2-10; sepals linear, acuminate, white-tomentose without, tomentulose within; capsules 1.1-1.7 cm. long, 9-13 mm. broad; valves about 2 mm. thick, subwoody to coriaceous, with a placenta bearing inconspicuous funicles. Wanganui, Central Volcanic Plateau, East Cape and Hawkes Bay, on the coast and inland.6. *P. ralphii*
 - bb. Flowers in axillary fascicles of 3, or solitary, or on very reduced lateral shoots if terminal; capsules relatively small and thin.
 - c. Shrubs or trees to 10 m. tall; young leaves, petioles, and sepals white-floccose-tomentose; flowers 1-3, usually subtended by 1 to several cataphylls; pedicels up to 2 cm. long; sepals oblong, acute; petals red to magenta; capsules trigonous, 1.2-2.0 cm. in diameter; valves slightly convex to flat in transverse section. Great Barrier Island and the Coromandel Peninsula.7. *P. buttonianum*

cc. Trees to 10 m. tall; young leaves and petioles brown-tomentose, sepals scantily puberulent to glabrous; flowers 1, rarely 2-3, usually subtended by a leaf; pedicels up to 1 cm. long; sepals ovate to oblong, sub-acute to obtuse; petals usually purple, occasionally maroon, pink, or white; capsules subglobose, 1.0-1.2 cm. in diameter; valves convex in transverse section. Throughout New Zealand8. *P. tenuifolium*

1. *PITTOSPORUM BRACTEOLATUM* Endl. Prodr. Fl. Norf. p. 78. 1833. (T.: *Bauer s.n.!*).

Trees to 7 m tall; branchlets grayish-brown, the young parts sparsely tomentulose, soon glabrate. Leaves alternate, frequently crowded at the tips of the branches, lanceolate-oblong to oblanceolate, acuminate, acute to attenuate at base, entire, 5 - 11 cm. long, 2.0 - 3.6 cm. broad, dark green above, paler beneath, glabrous, membranous, margins slightly revolute and undulate, costa immersed above, raised beneath, secondary veins 8 - 14 per side, anastomosing, obscure above, distinct beneath; petioles 4 - 9 mm. long, 1 - 2 mm. broad, sparsely tomentulose when young. Flowers terminal, 1 - 8, fascicled; pedicels 2 - 3 cm. long, accrescent and recurved in fruit, sparsely tomentulose when young, usually bearing a linear bract and subtended by a loose whorl of leaves and caducous, sparsely ciliate bud scales about 1 cm. long. Sepals free to the base, linear, acuminate, 10.0 - 13.5 mm. long, 2.5 - 3.0 mm. broad, with a few hairs on the main vein without; petals linear, acute, 1.5 - 2.0 cm. long, 4.0 - 4.5 mm. broad, free, spreading from the base, yellow-green; stamens 7.5 - 10.0 mm. long, anthers linear-oblong or sagittiform, 1.5 - 3.0 mm. long, 0.5 - 0.8 mm. broad. Pistil at anthesis slightly shorter than the stamens; ovary 4 - 7 mm. long, 1.5 - 5.0 mm. broad, tomentose; style 4.0 - 4.5 mm. long; stigma truncate. Capsules globose to pyriform, 3-valved, 2.0 - 3.5 cm. long, 1.5 - 2.5 cm. broad, brown-tomentose, glabrate, rugose; valves convex to slightly sulcate in transverse section, 3 - 5 mm. thick, woody, light yellow within, with a conspicuous placenta bearing 2 rows of short stout funicles from the base to the apex; seeds about 70, reddish-black, round to irregular.

Found only on Norfolk Island. Flowers in the winter months (June to August).

NORFOLK ISLAND: *Bauer s.n.* (K); in woods, *A. Cunningham* 26 (K); *Backhouse* 669 (K); on the margins of woods, *A. Cunningham s.n.*, 138 (K); *Mueller s.n.* (K); *Maiden & Boorman s.n.* (BM, K); *Paterson s.n.* (BM).

A flower which may have been female had a plump ovary 7 mm. long and 5 mm. broad, stamens 7.5 mm. long, and sagittiform, probably abortive, anthers 1.5 mm. long. The style was missing. Flowers which may have been male had slender ovaries 3.5 - 4.5 mm. long, 1.5 - 2.0 mm. broad, stamens 8.5 - 10.0 mm. long, and linear-oblong anthers 2.5 - 3.5 mm. long. The styles were 3.5 - 4.5 mm. long and the stigma was truncate.

2. *PITTOSPORUM ERIOLOMA* Moore & F. Muell. in F. Muell. Frag. Phyt. Austr. 7: 139. 1871. (T.: *Fullager s.n.!*).

Shrubs 2 - 5 m. tall; branchlets grayish-brown, the young parts brown-tomentose, soon glabrate. Leaves approximately verticillate, oblanceolate to obovate,

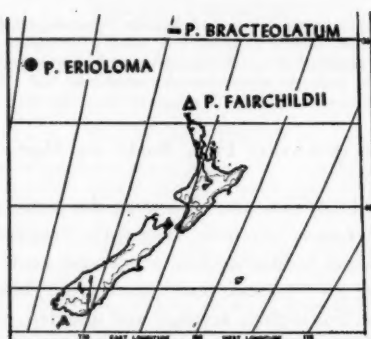


Fig. 8. *P. bracteolatum*, *P. erioloma*, and *P. fairchildii*.

acute at the apex and base, entire, or occasionally toothed or lobed when juvenile, 3-5 cm. long, 1.0-1.8 cm. broad, dark green above, paler beneath, glabrous, coriaceous, margins ciliate when young, glabrate, thickened and revolute when mature, costa raised above and beneath, secondary veins 7-9 per side, anastomosing, obscure above, distinct beneath; petioles 2-7 mm. long, 1-2 mm. broad, brown-tomentose when young. Flowers terminal, 2-7, fascicled; pedicels 1-2 cm. long, accrescent and recurved in fruit, brown-tomentose, subtended by a whorl of leaves and caducous, ciliate bud scales about 3 mm. long. Sepals imbricate at base, lanceolate, acute, 4-8 mm. long, 1.5-2.5 mm. broad, ciliate, glabrous without, brown-tomentose within; petals lanceolate-oblong, subacute, 15-18 mm. long, 3-4 mm. broad, free or coherent at the base, spreading from above the middle, cream-white with a reddish claw; stamens 7-11 mm. long, anthers sagittiform or elliptic-oblong, 1.5-3.5 mm. long, 0.5-1.00 mm. broad. Pistil at anthesis slightly shorter or longer than stamens; ovary 3-6 mm. long, 1-3 mm. broad, tomentose; style 2.0-4.5 mm. long; stigma 3-lobed and capitate, or truncate. Capsules globose, rarely subglobose or 3-lobed, 3-valved, 1.3-2.0 cm. in diameter, glabrous, rugose to slightly rugose, often accompanied by the persistent dried sepals; valves usually convex in transverse section, 3-6 mm. thick, coriaceous, light yellow within, with a conspicuous placenta bearing 2 rows of short stout funicles from the base to near the apex; seeds 11-23, black, round to irregular.

Mounts Lidgebird and Gower on Lord Howe Island; most common at elevations above 300 m. in "moss forest". Flowers during September and October.

LORD HOWE ISLAND: summit of Mt. Lidgebird, *Fullager s.n.* (MEL); *Fitzgerald s.n.* (AK); *King s.n.* (NSW); 600' to 1800', Mt. Lidgebird, *McComish 136, 136a* (K, NSW); summit of Mt. Gower, *Hedley & Dunn s.n.* (NSW); 1000', *Boorman s.n.* (NSW); Howe's Island, *Moore 9, 23* (K).

Flowers with 3-lobed capitate stigmas which protrude beyond the stamens, broad filaments, and small sagittiform anthers may be female as the anthers appear to be abortive. Flowers with truncate stigmas which do not protrude beyond the

stamens, narrower filaments, and larger elliptic-oblongoid anthers may be male as the ovary is small and thin.

Vernacular name: Lord Howe Island's Hedge Laurel.

3. *PITTOSPORUM FAIRCHILDII* Cheesem. in N.Z. Inst. Trans. & Proc. 20: 147. 1887. (T.: *Cheeseman s.n.!*).

Shrubs 3 - 5 m. tall; branchlets gray to brownish-gray, the young parts white-tomentose, soon glabrous. Leaves alternate, frequently crowded at the tips of the branches, obovate, elliptic-obovate or elliptic-oblong, obtuse or acute at apex, acute at base, entire, 4 - 7 cm. long, 2.0 - 3.5 cm. broad, light green above, paler beneath, white- to brown-tomentose when young, soon glabrous above but tomentulose beneath when mature, coriaceous, revolute, costa raised, secondary veins 7 - 11 per side, anastomosing, distinct; petioles 3 - 8 mm. long, 0.5 - 2.0 mm. broad, white- to brown-tomentose. Flowers terminal, 2 - 4, fascicled; pedicels 12 - 20 mm. long, accrescent in fruit, brown-tomentose, subtended by a whorl of leaves and caducous ciliate bud scales 5 - 10 mm. long. Sepals imbricate at base, lanceolate, acute, 4-7 mm. long, 2.0-3.5 mm. broad, brown-tomentose without, glabrous within, ciliate; petals lanceolate-oblong, subacute, 9 - 14 mm. long, 2.5 - 4.5 mm. broad, free, spreading from above the middle, purple; stamens 7.0 - 8.5 mm. long anthers sagittiform or elliptic-oblong, 1.5 - 2.5 mm. long, 0.5 - 1.3 mm. broad. Pistil at anthesis slightly longer to slightly shorter than the stamens; ovary 2.5 - 6.0 mm. long, 2 - 4 mm. broad, brown-tomentose; style 3 - 4 mm. long; stigma weakly capitate to truncate. Capsules subglobose, 3-valved, 2.0 - 2.5 cm. in diameter, tomentose, glabrate, rugose; valves convex in transverse section, 1.5 - 2.0 mm. thick, coriaceous, with a conspicuous placenta bearing two rows of minute funicles from the base to the apex; seeds 19 - 22, black, round.

Flowers in August.

NEW ZEALAND: THREE KINGS' ISLANDS: Great Island, *Cheeseman, s.n.* (AK, BM, K); *Baylis 22797* (AK); *Turbott 23023* (AK); *Turbott & Bell 22925* (AK); North East Island, *Buddle 22894* (AK).

Flowers which may be female have sepals up to 6.5 mm. long, petals up to 14 mm. long, sagittiform anthers only about 1.5 mm. long, weakly capitate stigmas exerted beyond the anthers, thin styles up to 3 mm. long, and stout ovaries 6 mm. long and 4 mm. broad. Flowers which may be male have sepals 4 - 7 mm. long, petals 9 - 13 mm. long, elliptic-oblong anthers about 2.5 mm. long, truncate stigmas level with or below the anthers, thicker styles 3.5 - 4.0 mm. long, and thin ovaries about 3.5 mm. long and 2.0 - 2.5 mm. broad.

Cultivated specimens from the Botanic Gardens, Cambridge (England), have been seen, *without collector s.n.* (K).

4. *PITTOSPORUM ELLIPTICUM* Kirk, in N.Z. Inst. Trans. & Proc. 4: 267. 1872. (T.: *Kirk s.n.!*).

Pittosporum ellipticum Kirk ssp. *ellipticum* Kirk, loc. cit. 1872. (T.: *Kirk s.n.!*).

Pittosporum ellipticum Kirk var. *decorum* Cheeseman, Man. N.Z. Fl. ed.2. p. 491. 1925. (T.: *Cheeseman s.n.!*).

Trees to 8 m. tall; branchlets dark brown, covered with appressed rusty tomentum when young, ultimately glabrate. Leaves alternate, crowded at the tips of the branches, elliptic-oblong to ovate or obovate, acute to obtuse at apex and base, entire, 3.5 - 9.7 cm. long, 1.5 - 4.8 cm. broad, covered with appressed rusty tomentum when young, soon glabrate above, sparsely tomentose to glabrate beneath, coriaceous, margins unthickened and slightly revolute, costa raised, secondary veins 7 - 10 per side, anastomosing, obscure above, distinct beneath; petioles 4 - 15 mm. long, 1.5 - 2.0 mm. broad, rusty-tomentose. Flowers terminal, 2 - 6, fascicled; pedicels 5 - 14 mm. long, accrescent in fruit, tomentose, subtended by a whorl of cataphylls and several caducous rusty-tomentose bud scales 1 - 2 mm. long. Sepals slightly imbricate at base, linear, acuminate, 8 - 11 mm. long, 2.0 - 2.7 mm. broad, rusty-tomentose without and to near the base within, ciliate; petals oblanceolate-linear, subacute, 14.0 - 19.5 mm. long, 3.0 - 4.5 mm. broad, free, recurved at the tips, reddish-brown to chocolate; stamens 7.2 - 11.0 mm. long, anthers sagittiform to oblong, 1.2 - 3.0 mm. long, 0.5 - 1.2 mm. broad. Pistil at anthesis slightly shorter or longer than the stamens; ovary 2.5 - 7.5 mm. long, 1.5 - 4.5 mm. broad, rusty-tomentose; style 1.5 - 6.5 mm. long, stigma capitate or truncate. Capsules subglobose, 3- or 2-valved, 1.5 - 2.0 cm. long, 1.3 - 1.7 cm. broad, rusty-tomentose to glabrate, slightly rugose; valves convex in transverse section, up to 1.5 mm. thick at the margins, much thickened at the apex, almost woody, with a thin raised placenta fused at the base, bearing flattened funicles up to 1 mm. long from the base to the middle; seeds 27 - 32, reddish-black, irregular.

Occurs in the hills in the North Auckland, Auckland, South Auckland, Thames and East Cape districts of the North Island of New Zealand. Flowers from August to November.

NEW ZEALAND: NORTH AUCKLAND: Whangaroa North, *Kirk s.n.* (AK); Mt. Manaia, *Kirk s.n.* (A, AK, GH, MO), 122 (K); same locality, *Cheeseman s.n.* (AK); Whangarei, *Kirk s.n.* (A), 623 (BM). AUCKLAND: Waitakere Ranges *Cheeseman s.n.* (AK, BISH, BM, K, US); same locality, *Meebold 5389* (BISH); same locality, Nihotapu, *Matthews, LeRoy & Carse s.n.* (AK); same locality, eastern side, *Bishop s.n.* (AK); Titirangi Ranges, *Cheeseman s.n.* (GH, K); roadside cliff, Huia, *Wood 27210* (AK); Anawhata, West Coast, *Cranwell s.n.* (K). THAMES DISTRICT: Ohinemuri Gorge near Karangahake, *Cheeseman s.n.* (AK); same locality, *Petrie s.n.* (AK); Gordon Settlement, near Te Aroha, *Downard s.n.* (AK). EAST CAPE: Hawai River, inland from Opotiki, *Field s.n.* (AK); 3000', Aorangi Scenic Reserve near Hikurangi, *Williams s.n.* (AK).

Flowers which may be male have truncate stigmas, styles 5.0 - 6.5 mm. long, ovaries 3.0 - 3.5 mm. long, about 2.5 mm. broad, and long stamens with oblong anthers up to 3 mm. long. Flowers which may be female have capitate stigmas, styles about 3 mm. long, ovaries 7.5 mm. long, 4.5 mm. broad, and short stamens with sagittiform anthers 1.2 - 1.5 mm. long, and about 0.5 mm. broad. Male flowers in which the pistil is only 4 mm. long also occur. It is difficult to decide whether this species belongs to the TRIVALVAE or BIVALVAE; Michie¹⁴⁶ has found trees with 3-valved fruits but the specimens I have seen in the Waitakere Ranges

¹⁴⁶ Personal communication.

have mostly 2-valved fruits. A yellow-flowered form is in cultivation in New Zealand.

Pittosporum ellipticum Kirk ssp. *ovatum* Kirk¹⁴⁷ is based on fruiting specimens collected at Whangaroa North over 80 years ago. Kirk¹⁴⁸ also cited Cheeseman's specimens from the Manaia Hills and the Titirangi district, but none of these match the description and the type collection from Whangaroa North. The Whangaroa district seldom has been visited by botanists and until more material is available the status of the subspecies is obscure. A specimen labelled var. *ovatum* in the Herbarium of the Royal Botanic Gardens, Kew (Kirk 105) resembles a broad-leaved form of *P. virgatum*.

Pittosporum ellipticum Kirk var. *decorum* Cheeseman was based on the collections of Cheeseman, Petrie, Downard, Field, and Williams, from the Thames and East Cape districts. Cheeseman wrote:

I am greatly puzzled with var. *decorum* which agrees exactly with the type in ferruginous tomentum, but differs in the inflorescence being both terminal and lateral. It has some points of agreement with *P. buttonianum* but never has the white floccose tomentum which is such a distinctive character when *P. buttonianum* is in bloom.

Cockayne identified Petrie's specimens from Karangahake as *P. buttonianum*, but a comparison of the characters of *P. ellipticum*, Cheeseman's var. *decorum*, *P. buttonianum*, and *P. ralpbii* shows that var. *decorum* has some characters in common with each of the other three species. *Pittosporum buttonianum* and *P. ellipticum* are found to the north, and *P. ralpbii* to the south of Cheeseman's var. *decorum*; and this last may possibly be representative of a heterozygous population derived through introgressive hybridization of the three species. *Pittosporum buttonianum*, *P. ellipticum*, and *P. ralpbii* occur mainly in areas which were not submerged in recent geological time. On the other hand, Cheeseman's var. *decorum* is found in localities which were beneath the sea during the Castlecliffian (upper Pliocene)¹⁴⁹, and it is possible that past geographical changes have been significant in the formation of the three peripheral species and the population represented by Cheeseman's var. *decorum*.

5. *PITTOSPORUM CRASSIFOLIUM* Banks & Soland. ex A. Cunn. in Ann. Nat. Hist. 4:106. 1839. (T.: *R. Cunningham* s.n.).

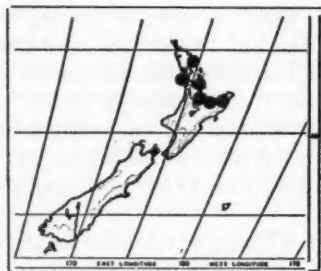
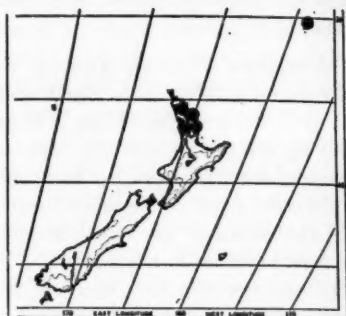
Pittosporum crassifolium var. *strictum* Kirk, in N.Z. Inst. Trans. & Proc. 4:266. 1872. (T.: Kirk s.n.).

Shrubs to small trees 1 - 10 m. tall; branchlets dark brown, the young parts white- or rusty-tomentose, becoming black. Leaves alternate, frequently crowded at the tips of the branchlets, obovate to oblanceolate, obtuse to acute at apex, attenuate at base, entire, 3 - 8 cm. long, 1 - 3 cm. broad, white- or brown-tomentose when young, soon glabrate above but densely appressed-tomentose beneath, coriaceous, margins thickened and strongly revolute, costa raised, secondary veins

¹⁴⁷ N.Z. Inst. Trans. & Proc. 4: 267. 1872. (T.: Kirk s.n.).

¹⁴⁸ *loc. cit.*, 1872.

¹⁴⁹ Fleming, in Tuatara 2: 80. 1949.

Fig. 9. *P. ellipticum*.Fig. 10. *P. crassifolium*

about 5 per side, anastomosing, usually obscure; petioles 4 - 14 mm. long 1 - 3 mm. broad, brown-tomentose. Flowers terminal, 1 - 10, fascicled; pedicels 0.6 - 5.0 cm. long, accrescent in fruit, tomentose, subtended by a whorl of leaves and numerous caducous, brown-tomentose, ciliate bud scales 3 - 15 mm. long. Sepals imbricate at base, oblong to linear-lanceolate, acute, 7 - 11 mm. long, 1.5 - 3.0 mm. broad, brown-tomentose without, and to above the middle within, ciliate; petals oblanceolate to lanceolate, subacute, 10 - 16 mm. long, 3 - 5 mm. broad, free, recurved at the tips, dark red to purple, becoming black on drying; stamens 5 - 9 mm. long, anthers sagittiform or elliptic-oblong, 1 - 3 mm. long, 0.5 - 1.5 mm. broad. Pistil at anthesis slightly shorter or longer than the stamens; ovary 3 - 6 mm. long, 2 - 5 mm. broad, tomentose; style 3.0 - 4.5 mm. long; stigma capitate and obscurely 3-lobed or truncate. Capsules trigonous, rarely 2- or 4-lobed, 3-valved, rarely 2- or 4-valved, 1 - 3 cm. long and broad, white- to brown-tomentose, rugose; valves concave in transverse section, 2 - 3 mm. thick, woody, with a conspicuous placenta bearing short stout funicles from the base to near the apex; seeds 20 - 36, black, irregular to round.

Common on the coast of Sunday Island in the Kermadec Islands group and on the coast of the northern portion of the North Island of New Zealand. Flowers in September and October.

KERMADEC ISLANDS: SUNDAY ISLAND: northern shore, *Cheeseman s.n.* (AK, K).
 NEW ZEALAND: NORTH AUCKLAND: Waiya—Rum Bay, *Wilkes s.n.* (K); on Flat Island, one of the Cavallos, *Hamilton s.n.* (K); Bay of Islands, *R. Cunningham s.n.* or 612 (K); at Matakauri, opposite the Cavallos, *R. Cunningham s.n.* or 612 (K, two labels, one *s.n.* and the other 612 are attached); Taranga (Hen) Island, *Moore & Cranwell s.n.* (AK); S.W. Island of Chickens group, *Moore & Cranwell s.n.* (AK); Southern Knight Island, Poor Knights Group, *Moore & Cranwell s.n.* (AK); Crayfish Island, 3 miles south of Helena Bay, *Olsen 10* (AK); Matakana, *Kirk s.n.* (P). AUCKLAND: Great Omaha, *Kirk s.n.* (A, GH, MO), 25 (BM); Kawau Island, *Kirk s.n.* (AK), 116 (K); David Island, *Molesworth 23320* (AK); coast near Auckland, *Cheeseman s.n.* (AK, BISH, K, NEW); same locality, *Petrie 6417* (A, NSW); Lake Pupuke, *Cheeseman s.n.* (AK, GH, NSW, US); Auckland, *Chapman s.n.* (A). THAMES: Tryphena Harbour, Great Barrier Island, *Osborne s.n.*

(AK) Great Barrier Island, *Matthews 1822* (AK); Little Barrier Island, *Kirk s.n.* (AK), 123 (K); Cape Colville, *Kirk s.n.* (US); Kennedy Bay, Coromandel, *Matthews s.n.* (AK, MO). WITHOUT DEFINITE LOCALITY: *Allison s.n.* (A, NSW); *Bidwill 198* (K); *Colenso s.n.* (K); *Cunningham 43* (U); C. [*Cunningham*] 2 (NSW); *Mueller s.n.* (CU, GH); *Wilkes s.n.* (GH); *Sinclair s.n.* (BM, MO).

Flowers which appear to be female have capitate, obscurely 3-lobed stigmas, styles about 3 mm. long, and plump ovaries about 6 mm. long and 5 mm. broad. The anthers are only about 1 mm. long, sagittiform, and the filaments are about 4 mm. long, markedly broad at the base. In the material which I have examined the flowers are solitary. On *Molesworth s.n.* two or three fruits occur together, and Cheeseman¹⁵⁰ describes female inflorescences as 1- to 5-flowered. Pedicels are markedly shorter at anthesis but elongate in fruit. Flowers which appear to be male have truncate stigmas, styles about 3.5 - 4.5 mm. long, slender ovaries about 3 mm. long and 2 mm. broad. The anthers are 2 - 3 mm. long, elliptic-oblong, and the filaments are 5 - 6 mm. long. In the material which I have examined the inflorescences are 2- to 8-flowered but Cheeseman¹⁵¹ describes them as 5- to 10-flowered. The pedicels of "male" flowers are markedly longer than those of "female" flowers.

Banks and Solander collected specimens of a species of *Pittosporum* on the east coast of New Zealand in 1769 and named it *P. crassifolium in herb.* but did not publish its description and figure. Allan Cunningham applied the name to specimens collected by his brother Richard, in 1833, "on Flat Island, one of the Cavallos Group, and at Matauri, etc." In the Herbarium of the Royal Botanic Gardens, Kew, the specimens are labelled:—"On Flat Island, one of the Cavallos, *Hamilton s.n.* [Dr. Hamilton of H.M.S. Buffalo, Dec. 1833]; Bay of Islands, *R. Cunningham s.n.* [612]; at Matauri, opposite the Cavallos, *R. Cunningham s.n.* [612]". Unfortunately, these collectings were of a different species from that discovered by Banks and Solander. Plants similar to those collected by Banks and Solander were subsequently described as *P. ralphii* by Thomas Kirk (N.Z. Inst. Trans. & Proc. 3: 161. 1871).

Kirk¹⁵² described *P. crassifolium* var. *strictum* from Little Barrier Island as a variety distinguished by having several erect fruiting pedicels clustered together, and smaller capsules. Solitary and clustered fruits occur on the same plants, however, and similar small-fruited plants, which grade into the larger-fruited form, have been found in a number of localities, e.g.: on Hen and Chicken Islands (*Moore & Cranwell s.n.*!, AK); Poor Knights Islands (*Moore & Cranwell s.n.*!, AK); Great Barrier Island (*Matthews s.n.*!, AK); and Crayfish Island, 3 miles south of Helena Bay (*Olsen 10!*, AK). *Kirk 123* (K), from Little Barrier Island, is also remarkable in having pedicels up to 5 cm. long but only one collection is available. Specimens collected on the Kermadec Islands (*Cheeseman s.n.*) also have markedly

¹⁵⁰ Man. N.Z. Fl. ed. 2. p.493. 1925.

¹⁵¹ loc. cit. 1925.

¹⁵² N.Z. Inst. Trans. & Proc. 4: 266. 1872. (T.: *Kirk s.n.*!).

narrow leaves, strict erect fruiting pedicels clustered together, and smaller capsules as in var. *strictum*. All these collections may be distinct but in the absence of flowers of the Kermadec plants and an adequate sample of the Little Barrier population they had best be left with *P. crassifolium*.

Two horticultural varieties are available to gardeners, but are not different in any important characters. A plant with yellow flowers was found at Tryphena Harbour, Great Barrier Island, some years ago (*Osborne s.n.*!) and is known in the trade as var. *album*. A form with variegated leaves is available as var. *variegatum* (Duncan & Davies Cat. Choice Nursery Stock, 47. 1947), but is not as vigorous as plants with green leaves. The latter are extensively used in New Zealand, the south of England, Spain, and California, as ornamentals and hedge plants.

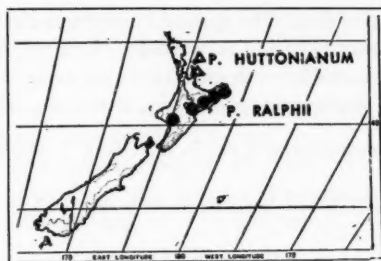
Vernacular name: *Karo*.

6. *PITTOSPORUM RALPHII* Kirk, in N.Z. Inst. Trans. & Proc. 3:161. 1871, ex char. (T.: *Ralph s.n.*).

Pittosporum crassifolium Banks & Soland. ex Kirk, Students' Flora N.Z. p. 51. 1899, nom. nud. in synonym.

Shrubs 2.5 - 4.0 m. tall; branchlets grayish-brown, white- to buff-tomentose, glabrate. Leaves alternate, frequently crowded at the tips of the branchlets, oblong to obovate, occasionally oblanceolate or elliptic, obtuse or acute at apex, acute or obtuse at base, entire, 4 - 12 cm. long, 2 - 4 cm. broad white- to buff-tomentose when young, soon glabrate above but densely appressed-tomentose beneath, coriaceous, margins unthickened, flat, or revolute, costa raised or immersed above, raised beneath, secondary veins about 9 - 12 per side, anastomosing, distinct in juvenile leaves, obscure in adult leaves; petioles 8 - 22 mm. long, 1 - 3 mm. broad, white- to brown-tomentose. Flowers terminal on long leading or short axillary shoots, 2 - 10, fascicled; pedicels 6 - 14 mm. long, accrescent in fruit, tomentose, subtended by a single leaf or several cataphylls and tomentose bud scales 3 - 18 mm. long, apparently pedunculate on the shedding of leaves, cataphylls, and bud scales. Sepals imbricate at base, linear, acuminate, 7 - 11 mm. long, 1.5 - 3.0 mm. broad, white-tomentose without, tomentulose within, ciliate; petals oblanceolate-linear to oblong-linear, obtuse to subacute, 11 - 18 mm. long, 2 - 4 mm. broad, free, recurved at the tips, dark red to purple; stamens 4.5 - 9.0 mm. long, anthers sagittiform to oblong, 1.0 - 3.5 mm. long, 0.5 - 1.0 mm. broad. Pistil at anthesis slightly shorter or longer than the stamens; ovary 2.5 - 4.0 mm. long, 1 - 2 mm. broad, white-tomentose; style 2 - 5 mm. long; stigma capitate. Capsules trigonous, rarely 2-lobed, 3-, rarely 2-valved, apiculate, 11 - 17 mm. long, 9 - 13 mm. broad, white-tomentose, glabrate, rugose; valves concave in transverse section, about 2 mm. thick, coriaceous to slightly woody, with a conspicuous placenta bearing minute funicles from the much-thickened base to above the middle; seeds 9 - 17, black, irregular to round.

Found from Patea and Wanganui on the west coast to East Cape and Cape Kidnappers on the east coast of the North Island of New Zealand. Flowers from October to December.

Fig. 11. *P. ralphii* and *P. huttonianum*.

NEW ZEALAND: EAST CAPE: Hendley Station, *Hodgson s.n.* (AK); bridge beyond Okawa, *Meebold 18279* (BISH); prope Tolaga, Opuragi and Totaranui, *Banks & Solander s.n.* (BM); Tolaga Bay, East Cape, *Banks & Solander s.n.* (AK, MO, US); coast near Gisborne, *Townson s.n.* (AK, BM); Patangata, *Hamilton s.n.* (AK); Havelock North, *Meebold 4823, 5564* (BISH); Pourere, *Kirk s.n.* (MO); Pitane, *Kirk s.n.* (A, GH); 700', Te Reinga Falls, near Waikaremoana, *Sainsbury s.n.* (AK); Wairoa, *Sainsbury 164, 622, 623, 624, 708, 709, 710, 711* (AK, MO); Waikaremoana, *Cranwell & Moore s.n.* (AK); same locality, near outlet, in forest, *Oliver s.n.* (AK); road bank near Te Araroa, *Moore & Cranwell s.n.* (AK); Mokoheka, *Meebold 18280* (BISH). WANGANUI: near Taumarunui, *Kirk s.n.* (AK); Upper Wanganui River, *Allison s.n.* (A, NSW); Patea, *ex hort.*, *Cheeseman s.n.* (GH); same locality, *ex hort.*, *Hector s.n. 176* (K); same locality, *ex hort.*, *Kirk 616* (K). WITHOUT LOCALITY: *Colenso 206, 344* (K); *Kirk s.n.* (P).

Flowers which may be female have capitate stigmas, styles about 2 mm. long, and plump ovaries about 4 mm. long and 2 mm. broad. The anthers are probably sterile, sagittiform, 1.0 - 1.5 mm. long, and the filaments are 3.0 - 3.5 mm. long, markedly broad at the base, tapering distally. Flowers which appear to be male have weakly capitate stigmas, styles 3.5 - 5.0 mm. long, and slender ovaries 2.5 - 3.5 mm. long, and 1 - 2 mm. broad. The anthers are oblong, 3.0 - 3.5 mm. long, and the filaments are 4 - 6 mm. long, not markedly broad at the base. On one specimen (*Cheeseman s.n. ex hort.*), several flowers were found with 4 functional stamens about 9 mm. long and one apparently sterile stamen about 6 mm. long. The functional stamens had oblong anthers about 3 mm. long while the apparently sterile stamens had sagittiform anthers only 1 mm. long. The stigmas were weakly capitate, the styles long, and the ovaries slender as in male flowers. Godley¹⁵³ has informed me that the species is dioecious.

It has long been known that Banks and Solander collected specimens of *P. ralphii* at Tolaga Bay on the east coast of the North Island of New Zealand during Cook's first voyage to the South Seas in 1769-1772, and named it *P. crassifolium in herb*, but their description and plate were never published and the name *P. crassifolium* was later applied by A. Cunningham to specimens of another species collected by his brother, R. Cunningham, in North Auckland. *Banks & Solander s.n.*, BM) consists, however, of two sheets of *P. ralphii* Kirk and one sheet of *P.*

¹⁵³ Personal communication.

crassifolium A. Cunn (sterile). The type of *P. ralphii* is a collection made by Dr. Ralph at Wanganui about 1870 and forwarded to Kirk for description.

A form with variegated leaves is available in the trade in New Zealand. The species is cultivated in England (Isles of Scilly, Penzance, Allerford, etc.).

7. *PITTIOSPORUM HUTTONIANUM* Kirk, in N.Z. Inst. Trans. & Proc. 2: 92. 1870. (T.: Kirk s.n.).

Pittosporum huttonianum Kirk var. *fasciatum* Kirk, Students' Fl. N.Z. p. 48. 1899. (T.: Kirk s.n.).

Shrubs or trees to 10 m. tall; branchlets dark brown, covered with floccose white tomentum when young, glabrate. Leaves alternate, frequently crowded at the tips of the branchlets, elliptic-oblong to obovate-oblong, acute to obtuse at apex and base, entire, 4.2 - 12.0 cm. long, 2.1 - 5.0 cm. broad, covered with floccose white tomentum when young, glabrate, slightly coriaceous, margins unthickened, flat or undulate, occasionally revolute, costa level or sunken above, raised beneath, secondary veins about 12 per side, anastomosing, obscure above, distinct beneath; petioles 5 - 15 mm. long, 1.0 - 2.5 mm. broad, covered with appressed white tomentum when young, glabrate. Flowers terminal and axillary, solitary or in fascicles of 3; pedicels up to 2 cm. long, accrescent in fruit, white-tomentose, usually subtended by 1 to several cataphylls and caducous tomentulose or glabrous bud scales 2 - 10 mm. long. Sepals slightly imbricate at base, oblong, acute, 6 - 9 mm. long, 2.2 - 3.0 mm. broad, covered with floccose white tomentum without, glabrous within; petals oblanceolate-linear, obtuse to subacute, 12 - 18 mm. long, 3.0 - 4.2 mm. broad, free, recurved above the middle, red to magenta; stamens 6 - 10 mm. long, anthers sagittiform to oblong, 1.5 - 4.5 mm. long, 0.8 - 1.5 mm. broad. Pistil at anthesis slightly shorter or longer than the stamens; ovary 2.6 - 5.0 mm. long, 1.0 - 3.5 mm. broad, white-tomentose; style 2.0 - 5.5 mm. long; stigma weakly capitate or truncate. Capsules trigonous, 3-valved, rarely 2-valved, apiculate, 1.2 - 2.0 cm. in diameter, white-tomentose, glabrate, weakly rugose; valves slightly convex to flat in transverse section, about 1 mm. thick, coriaceous, with a thin placenta, fused at the base, bearing flattened funicles up to 1 mm. long from the base to above the middle; seeds 18 - 23, reddish-black to black, irregular.

Occurs on the Great Barrier Island and the Coromandel Peninsula in the North Island of New Zealand. Flowers from October to November.

NEW ZEALAND: THAMES: Great Barrier Island, Kirk s.n. (A, K, US), 86 (K), 518 (BM); Kaiarara, same locality, Kirk s.n. (AK, GH, MO); Kaiwiriki, same locality, Kirk s.n. (AK); timber track, Whangaparapara, same locality, Molesworth s.n. (AK); same locality, Matthews & Carse s.n. (AK); same locality, Hynes 26567 (AK, MO); Kennedy Bay, Coromandel, Matthews s.n. (AK, MO); 1600', Castle Rock, Coromandel, Cbeeseman s.n. (AK, GH); same locality, Petrie 6418 (A); same locality, Cranwell & Moore s.n. (AK); Table Mountain behind Thames, Adams s.n. (AK); Pakirerehi, Adams s.n. (AK); same locality, Cbeeseman s.n. (US); Kawaeranga, Hector 176 (K).

Pittosporum huttonianum var. *fasciatum* was characterized by flowers in terminal cymes and peduncles white with floccose tomentum. The "peduncles" are the young shoots which have not developed a subtending whorl of leaves or

cataphylls. This phenomenon occurs in the development of the inflorescence of other species and does not merit varietal status.

Flowers which may be female have weakly capitate stigmas on styles about 2 mm. long, plump ovaries 4.8 - 5.0 mm. long, 3.5 mm. broad, and short stamens 6 mm. long, with sagittiform anthers 1.5 mm. long, 0.8 mm. broad. Flowers which may be male have truncate stigmas on styles 3.5 - 5.5 mm. long, slender ovaries 2.6 - 4.0 mm. long, 1 - 2 mm. broad, and stamens 6.8 - 10 mm. long with oblong anthers 2.8 - 4.5 mm. long, 1.0 - 1.5 mm. broad.

8. *PITTOSPORUM TENUIFOLIUM* Banks & Soland. ex Gaertn. Fruct. et Sem. 1: 286. *t.* 59. 1787-88. (T.: *Banks & Solander s.n.!*).

Trees to 10 m. tall; branchlets grayish-brown, tomentose when young, glabrate. Leaves alternate, frequently crowded at the tips of the branchlets, oblong, obovate or elliptical, acute to obtuse at apex and base, entire, 1.5 - 12.2 cm. long, 1.2 - 4.7 cm. broad, green above, sometimes marked with purple, paler beneath, sparsely tomentose when young, soon glabrate, slightly to strongly coriaceous, margins unthickened, flat, revolute, or undulate, costa sunken above, raised beneath, secondary veins 6 - 12 per side, anastomosing, obscure above, distinct or obscure beneath; petioles 3 - 12 mm. long, 0.5 - 2.5 mm. broad, glabrous. Flowers axillary, 1 - 3, solitary or fascicled, subtended by a whorl of caducous bud scales, occasionally terminal on short axillary shoots and subtended by 1 - 2 cataphylls or leaves, and several caducous linear bracts, sessile or on pedicels up to 1 cm. long, tomentose, accrescent in fruit. Sepals slightly imbricate at base, ovate to oblong, subacute to obtuse, 3 - 7 mm. long, 1.4 - 4.5 mm. broad; petals oblanceolate-linear to spatulate and clawed, obtuse, 8 - 16 mm. long, 2 - 5 mm. broad, free, reflexed from the middle, dark purple, maroon, pink or white; stamens 3.6 - 8.0 mm. long, anthers sagittiform to oblong, 1 - 4 mm. long, 0.5 - 1.0 mm. broad. Pistil at anthesis slightly shorter or longer than the stamens; ovary 2.5 - 4.5 mm. long, 1 - 3 mm. broad, tomentose; style 2.0 - 3.5 mm. long, stigma capitate or truncate. Capsules subglobose, apiculate, 3-valved, rarely 2- or 4-valved, 9 - 14 mm. in diameter, tomentose, glabrate, weakly rugose; valves 1.0 - 1.5 mm. thick, coriaceous, convex in transverse section, with a placenta raised and fused at the base, bearing peg-like or flattened funicles from the base to above the middle; seeds 6 - 31, black, irregular.

KEY TO THE SUBSPECIES

- Leaves oblong-ovate to elliptic-obovate, obtuse to shortly acuminate, 1.5-6.0 cm. long, 1-3 cm. broad, membranous to slightly coriaceous, frequently marked with purple when young, margins often undulate; sepals usually obtuse, 2.5-4.5 mm. long, 1.5-3.6 mm. broad, tomentose to glabrate. Throughout New Zealand, at lower elevations8a. *P. t. tenuifolium*
- Leaves lanceolate-oblong to obovate-oblong, acute to shortly acuminate, 3.9-12.2 cm. long, 1.1-4.7 cm. broad, coriaceous, not marked with purple, margins usually flat; sepals subacute, 4.5-6.0 mm. long, 2.5-4.0 mm. broad, tomentulose to glabrate. From the Waikato and Volcanic Plateau southwards, at higher elevations.8b. *P. t. colensoi*

8a. *PITTOSPORUM TENUIFOLIUM* ssp. *tenuifolium*

Trichilia monophylla A. Rich. in Less. & A. Rich. Voy. l'Astrolabe, Bot. Ess. Fl. N. Zel. p. 306. pl. 34. 1832, ex char. & icon. (T.: d'Urville s.n.).

Pittosporum translucens Hook. ex Putterl. Syn. Pittosp. p. 13. 1839, nom. nud. in synonym.

Pittosporum mayi Hort. Regel, Cat. Pl. Hort. Aksakow, p. 112. 1860, nom. nud.

Pittosporum enderi Regel, in Gartenfl. 17: 226. t. 587. 1868, ex char. & icon.

Pittosporum bidwillianum Regel, loc. cit. 1868, nom. nud.

Pittosporum tenuifolium Gaertn. var. *tenuifolium* Kirk, Students' Fl. N.Z. p. 47. 1899.

Pittosporum nigricans Hort. Davy in Bailey, Cycl. Amer. Hort. 3: 1360. 1901, nom. nud. in synonym.

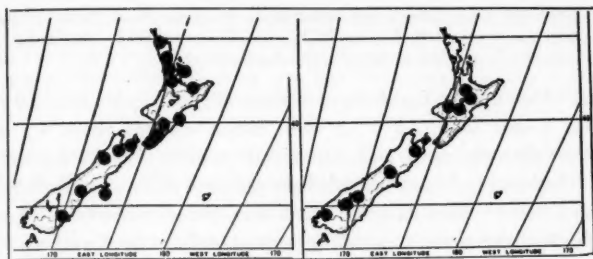
Occurs from the North Auckland district in the North Island to the Otago District in the South Island of New Zealand, at lower elevations than ssp. *colensoi*. Flowers from September to November.

NEW ZEALAND: NORTH AUCKLAND: Kaitaia, R. H. Matthews s.n. (AK); same locality, H. B. Matthews s.n. (AK); same locality, Kelly's Bush, R. H. Matthews s.n. (AK, MO); Kaiaka, Trig Track, Carse s.n. (AK, MO); near sea level on south bank of Oruru River, Taipa, in remnant of *Agathis* forest, Cooper 36006, 36014 (AK, MASS, MO); Bay of Islands, A. Cunningham s.n. (BM); same locality, Wilkes s.n. (K, US); Wangaroa, R. Cunningham 43 (K); Maungatapere, near Whangarei, Carse s.n. (AK). AUCKLAND: Omaha, Kirk 83 (GH), 85 (BM); Glenfield, Birkdale, H. B. Matthews s.n. (AK, MO); Auckland, Hector s.n. (GH); same locality, Kirk 85 (US); same locality, Kirk 54 (AK); Waitakere, Cheeseman s.n. (US); Titirangi Ranges, Cheeseman s.n. (AK); 1300', same locality, Meebold 5410 (BISH, K); Huia, Wood s.n. (AK). THAMES: Coromandel Peninsula, Adams s.n. (AK); Tapapa, Cheeseman s.n. (AK, BISH, NSW). WAIKATO: Buckland, H. B. Matthews s.n. (AK). EAST CAPE: Te Whaiti, Urewera, H. B. Matthews s.n. (AK); Lake Waikaremoana, Moore & Cranwell s.n. (AK); Wairoa South, Cheeseman s.n. (AK); 2000', Blowhard, Meebold 18277 (BISH); 1500', Tongioio, Meebold 18282 (BISH); Havelock North, Meebold 18283 (BISH). VOLCANIC PLATEAU: Murimohu, Ohakune, Attwood s.n. (AK). WAIRARAPA: 70 Mile Bush, Colenso s.n. (K). WELLINGTON: Palmerston North, Allan s.n. (BH); Lower Hutt, Kirk s.n. (NSW); in dry woods, sheltered valley, Day's Bay, 150', MacDaniels s.n. (CU). MARLBOROUGH: Kenepuru, Pelorus Sounds, MacMahon 205 (AK). NELSON: Maitai Valley, Mellor 27212 (AK); 500', same locality, near stream on damp graywacke soil, Neal 10 (BISH). CANTERBURY: Banks Peninsula, Kirk 54 (AK); same locality, Haast 69 (K); same locality, Lyttelton Hills, Meebold 4739 (BISH); same locality, Akaroa, Belligny s.n. (GH, K); Peel Forest, Meebold 4096 (BISH); 800', Waiau River, Morrison 33 (A); Ashley Gorge, Meebold 5845 (BISH); in mixed forest, Orari Gorge, Anderson 75 (A, K, MO, US). WESTLAND: Cape Foulwind, Townson 670 (AK); foot of Mt. Rochfort, Townson 669 (AK); without definite locality, Armstrong s.n. (AK). OTAGO: Arrowtown, Petrie s.n. (AK); Dunedin, Hector s.n. (K). WITHOUT LOCALITY: Banks & Solander s.n. (AK, BM labelled "prope Tolaga, Oporagi, Ouhuragi, Totaranui, MO, US"); Colenso s.n. (AK), s.n., 714 (K); A. Cunningham 11 (U), s.n., 615 (K); Kirk s.n. (A, MO, NSW, US); Sinclair s.n. (BM, MO); Raoul s.n. (A).

Flowers which may be female have capitate, obscurely lobed stigmas, styles about 2 mm. long, ovaries about 3 mm. long, 2 mm. broad, stamens 3.6 - 4.5 mm. long, slightly shorter than the pistil, and sagittiform, possibly abortive anthers about 1.4 mm. long. Flowers which may be male have truncate stigmas, styles 2.5 - 3.0 mm. long, ovaries 2.5 - 4.0 mm. long, 1.0 - 1.5 mm. broad stamens 6.0 - 7.5 mm. long, slightly exceeding the pistil, and oblong, probably functional anthers 2 - 4 mm. long. Godley¹⁵⁴ has informed me that the species is dioecious.

Vernacular names: *Mapauriki* (Sinclair s.n.), *Kobuhu*, *Tawhiwhi*.

¹⁵⁴ Personal communication.

Fig. 12. *P. tenuifolium* ssp. *tenuifolium*.Fig. 13. *P. t.* ssp. *colensoi*.

8b. *PITTOSPORUM TENUIFOLIUM* ssp. *COLENSEI* (Hook.f.) Kirk, in N.Z. Inst. Trans. & Proc. 4: 262. 1872.

Pittosporum colensoi Hook. f. Fl. N.Z. 1: 22. 1853. (T.: Colenso s.n.!).

Pittosporum viride Hook.f. loc. cit. 1853, nom. nud. in synonym.

Pittosporum uniflorum Hook. f. loc. cit. 1853, nom. nud. in synonym.

Pittosporum fasciculatum Hook.f. loc. cit. 24. 1853. (T.: Colenso s.n.!).

Pittosporum tenuifolium Gaertn. ssp. *fasciculatum* (Hook.f.) Kirk, in N.Z. Inst. Trans. & Proc. 4: 262. 1872.

Pittosporum tenuifolium Gaertn. var. *colensoi* (Hook.f.) Kirk, Students' Fl. N.Z. p.47. 1899.

Pittosporum tenuifolium Gaertn. var. *fasciculatum* (Hook.f.) Kirk, loc. cit. 1899.

Pittosporum tenuifolium Gaertn. var. *fasciculatum* (Hook.f.) Kirk, sub. var. *cymosum* Kirk, loc. cit. 1899. (T.: Williams s.n.!).

Pittosporum buttonianum Kirk var. *viridiflorum* Kirk, loc. cit. 1899. (T.: Kirk s.n.!).

Pittosporum colensoi Hook. f. var. *fasciculatum* (Hook.f.) Cheesem. Man. N.Z. Fl. 53. 1906.

Occurs from the Waikato and Volcanic Plateau in the North Island to the Otago district in the South Island of New Zealand, usually at higher elevations than ssp. *tenuifolium*. Flowers in November.

NEW ZEALAND: WAIKATO: Hora Hora, Petrie 764/4 (K). TARANKI: Urenui, Cheeseman s.n. (AK); roadside near Tarata, Carse 764/6 (K). VOLCANIC PLATEAU: Rotorua, Petrie & H. B. Matthews s.n. (AK); same locality, Turner 159 (AK); same locality, Kohuturoa Creek, Kirk 54 (AK), 564 (K); Patetere Plateau, Cheeseman s.n. (AK); near Taupo, Colenso s.n. (AK), 2361 (K as *P. viridum*, type of *P. fasciculatum*); in jungle filled gorge dominated by tree ferns, near the Raurimu spiral, National Park, Walker 4316 (MO, US); 3500', base of Ngauruhoe, Cheeseman s.n. (AK); near Tongariro, Kirk s.n. (MO); same locality, Hodgkins s.n. (AK); 4000', ½ m. west of Chateau Tongariro, Attwood s.n. (AK); near Haunted Whare, Waimarino, H. B. Matthews s.n. (AK); Waimarino Plains, H. B. Matthews 764/11 (K); same locality, Zotov s.n. (BH); Makino Valley, Manganui-a-te-ao, Waimarino, Attwood s.n. (AK); 1200', Ohakune, MacDaniels 1225 (BISH); 2000', same locality, Meebold 18276 (BISH). NELSON: between Nelson and Havelock, Sledge 266 (K). MARLBOROUGH: Awatere River, H. J. Matthews s.n. (AK); same locality, Petrie s.n. (AK); same locality, 2000', in bush, Travers s.n. (GH). CANTERBURY: Arthurs Pass, Halpin's, Moore & Cranwell s.n. (AK). WESTLAND: Otira Gorge, Cheeseman s.n. (AK); Anita Bay, Dusky Sound, Aston s.n. (AK). OTAGO: Pigeon Island, Lake Wanaka, Hunnewell 13466 (GH); Lake Wanaka District, Hector s.n. (GH); Paradise, near Lake Wakatipu, Turner 816 (AK); Wakatipu, Meebold 4442 (BISH); Clinton Valley, Lake Te Anau, 800', Petrie 140 (K);

Chalky Bay, *Lyall s.n.* (K); Otago, not common N. of Dusty Bay, *Hector & Buchanan 22* (K). WITHOUT LOCALITY: *Bell s.n.* (NSW); *Colenso s.n.*, (*P. uniflorum*, AK), *s.n.* (*P. viride*, K), 2367 (*P. uniflorum*, K); *Dieffenbach s.n.* (K).

Flowers which may be female have capitate stigmas, styles 1.6 - 2.0 mm. long, ovaries about 4 mm. long, 2.5 - 3.0 mm. broad, stamens about 4.5 mm. long, slightly shorter than the pistil, and sagittiform, possibly abortive anthers 1.0 - 1.2 mm. long. Flowers which may be male have truncate stigmas, styles 3.0 - 3.5 mm. long, ovaries 3.0 - 4.5 mm. long, 1.5 - 2.0 mm. broad, stamens 6 - 8 mm. long, slightly exceeding the pistil, and oblong, probably functional anthers 2 - 3 mm. long.

Vernacular name: *Mountain Kobuhu*.

The two subspecies of *P. tenuifolium* are used in New Zealand, the United States (California), France, southern England, and the Scilly Islands, the Channel Islands (Guernsey), Italy, and Australia, for hedges and ornamental trees. In New Zealand the two subspecies have been so mixed in plantings and so extensively planted that it is difficult to determine their original distribution. Furthermore, they intergrade and it is sometimes impossible to determine the subspecies to which a specimen belongs. Transplantings of trees selected from wild populations at different altitudes are required to determine the extent to which variation in the species is caused by the habitat.

Pittosporum fasciculatum Hook. f. was established to include forms which have flowers in terminal and axillary fascicles. Both *P. t. tenuifolium* and *P. t. colensoi* occasionally have fascicled flowers, and fascicled and solitary flowers are frequently found together in the other species of *Pittosporum* with simple inflorescences. Consequently I do not think that the plants with fascicled flowers should be treated as a distinct species.

Pittosporum buechanani Hook. f. was based on specimens from a plant cultivated at Wellington by Buchanan and reputed to come from near Tongariro. The type specimen at Kew has only "New Zealand" as the locality. Specimens identified as *P. buechanani* were subsequently collected, possibly at Kaitaia, by Buchanan, on Mt. Egmont, by Hector, and by Kirk in the Wellington district. The specimen at Kew, collected by Buchanan, as noted "... the exact place where found is uncertain but probably between Hokianga and Bay of Islands." In the last 50 years the Kaitaia, Mt. Egmont, and Wellington districts have been thoroughly explored but no further specimens have been obtained. I have treated the name *P. buechanani* as doubtful because the specimens are too few and imperfect to determine the status of it.

Pittosporum intermedium Kirk was based on specimens from a single tree on Kawau Island. The tree was subsequently destroyed and no others have been found. In describing the species Kirk¹⁵⁵ wrote:

¹⁵⁵ N.Z. Inst. Trans. & Proc. 4: 266. 1872.

I give this well-marked form specific rank with some hesitation; in foliage it resembles large forms of *P. tenuifolium*, while the capsule partakes of the characters of *P. crassifolium* and *P. ellipticum*. Dr. Hooker and Mr. Colenso consider it a new species, still it is possible that further observation may show the wisdom of uniting it with one or other of the above. I have been tempted to attribute its peculiarities to hybridisation.

A sheet at British Museum is noted by H. H. Allen: "very probably *P. ellipticum* \times *tenuifolium*". The few specimens available to me match *P. umbellatum* in the size and shape of the sepals and petals, but lack the typical large terminal inflorescence and lobed capsules. I have treated the name *P. intermedium* as doubtful under the circumstances.

The following cultivated forms of *P. tenuifolium* are available in New Zealand:

P. tenuifolium "garnettii". Duncan & Davies, Catalogue of trees, shrubs and climbers, p. 62. 1950-51.—Leaves edged with white, flecked or tinged with red.

P. tenuifolium "purpureum". *loc. cit.* Suppl. list 1950-51.—Leaves deeply tinged with purple.

P. tenuifolium "variegatum". *loc. cit.* p. 62. 1950-51.—Leaves edged with white or cream.

P. tenuifolium "argenteum". *loc. cit.* p. 32. 1953-54.—This form has been offered for sale as *P. tenuifolium* "Silver Matipo". *loc. cit.* p. 62. 1950-51, and p. 81. 1954-55, but no description is given. It may be the same as *P. nigricans* var. "Silver Queen" which is described (R.H.S. Dictionary of Gardening, 3: 1595. 1951), as having silvery-gray foliage, but I have not seen specimens of "Silver Queen". *Pittosporum tenuifolium* "argenteum" and "variegatum" were introduced into cultivation prior to 1950 but the references are to the earliest dated catalogues which I have found.

Davy¹⁵⁶ lists *P. nigra* Hort? as a horticultural name of *P. tenuifolium* and Hector noted on a sheet in the herbarium of the Royal Botanic Gardens, Kew (*Hector s.n.*) that *P. tenuifolium* was named *P. nigrum* by the Sydney Botanic Gardens in 1862. Lord¹⁵⁷ gives *P. nigrescens* as another horticultural name for *P. tenuifolium*. A form with markedly undulate leaves is available in Europe as *P. mayi*, and its origin and status are described in detail by Gadeceau¹⁵⁸.

¹⁵⁶ Davy in Bailey, Cycl. Amer. Hort. 3: 1360. 1901.

¹⁵⁷ Lord, Shrubs & Trees for Australian Gardens, p. 34. 1948.

¹⁵⁸ Bull. Soc. Bot. Fr. 67: 153. 1920.

SERIES II. BIVALVAE

SERIES II. BIVALVAE Gowda, in Jour. Arnold Arb. 32:285. 1951

KEY TO THE SPECIES

- a. Inflorescences simple; flowers solitary or in fascicles of few to many (rarely in 3- to 4-flowered cymes in *P. phillyraeoides*).
- b. Terrestrial trees or shrubs; flowers terminal and axillary; petals purple, red or yellow; capsules globose to ovoid (ellipsoid in *P. obcordatum*). Australia and New Zealand.
- c. Plants without persistent diverse juvenile foliage. Australia.
- d. Unarmed trees and shrubs; flowers subterminal and axillary, solitary or in fascicles of 2-4.
- e. Shrubs or small trees 3-10 m. tall; branches pendulous; leaves glabrous; petals yellow or white; capsule valves woody, 1.0-3.5 thick. Throughout continental Australia 9. *P. phillyraeoides*
- ee. Shrubs or small trees 6-16 m. tall; branches ascending; leaves tomentose beneath; petals yellow marked with red to purplish-red; capsule valves coriaceous, less than 1 mm. thick. New South Wales, Victoria, and Tasmania. 10. *P. bicolor*
- dd. Spinose shrubs; flowers axillary or terminal, on arrested branchlets, solitary. Southeast Queensland, at high altitudes. 11. *P. o'reillyanum*
- cc. Plants with persistent diverse juvenile foliage (juvenile and adult leaves linear in *P. pimeleoides*). New Zealand.
- d. Flowers large, terminal on normal branchlets, 1-20; capsules 6-16 mm. long; seeds up to 18, black, irregular.
- e. Branchlets never sharply divaricate or matted.
- f. Trees to 8 m. tall or more; sepals usually acute; capsule valves concave or sulcate to convex in transverse section.
- g. Trees to 10 m. tall; flowers up to 20; sepals, pedicels, young leaves, and petioles glabrous; petals red; capsules usually 4-lobed; valves usually concave in transverse section. North Auckland and Thames. 12. *P. umbellatum*
- gg. Trees to 8 m. tall; flowers 1-6; sepals, pedicels, young leaves and petioles rusty-tomentose; petals usually dark red to purple; capsules subglobose; valves sulcate to convex in transverse section. North Auckland and Thames 13. *P. virgatum*
- ff. Shrubs 0.5-5.0 m. tall; sepals usually acuminate; capsule valves convex to weakly sulcate in transverse section.
- g. Shrubs 0.5-2.0 m. tall; male flowers 6-9, female flowers 1; petals cream to yellow with a red stripe; capsules ovoid, acuminate or almost beaked at apex. North Auckland. 14. *P. pimeleoides*
- gg. Shrubs 1-5 m. tall; flowers 3-7; petals purple; capsules globose to subglobose, obtuse at apex. Nelson. 15. *P. patulum*
- oe. Branchlets sharply divaricating and matted at juvenile stage or on lower part of adult stem; shrubs or trees 2-9 m. tall; flowers 4-12; petals pink to purple; capsules globose. Volcanic Plateau. 16. *P. turneri*
- dd. Flowers minute, axillary or terminal, on arrested branchlets (terminal on normal branchlets in *P. rigidum*), in few-flowered fascicles or solitary; capsules 4.5-10.0 mm. long; seeds 1-9, reddish-black to black, round to irregular.
- e. Trees or shrubs 2-6 m. tall; petals linear-oblong, usually purple; capsule valves dehiscent without, leaving a persistent papery endocarp.
- f. Adult leaves orbicular to obovate, obcordate to obtuse at apex, with 2-4 usually distinct secondary veins per side; petioles usually narrowly winged; flowers 1-5, axillary or terminal, on minute arrested branchlets; sepals persistent, tomentulose; petals pale purple, yellow, or white; capsules ellipsoid to sub-ovoid; placentas with funicles from the base to the middle. North Auckland, Hawkes Bay, and Canterbury. 17. *P. obcordatum*
- ff. Adult leaves rarely orbicular to obovate, obtuse to subacute at apex, with obscure secondary veins; petioles without wings; flowers usually solitary (1-3 in *P. crassicaule*), axillary or terminal, on normal or arrested branchlets; sepals caducous, glabrous; petals purple; capsules cordate or subglobose to globose; placentas with funicles near the middle.

- g. Shrubs to 3 m. tall; branchlets ascending, not spinose; leaves obtuse at base; pedicels 0.5–4.0 mm. long; flowers solitary, terminal or axillary on normal branchlets; sepals 3.5–6.0 mm. long, 1.0–1.5 mm. broad; petals 8–12 mm. long, 2 mm. broad; ovary tomentose; capsules subglobose, 8–10 mm. long, 6–10 mm. broad. Hawkes Bay, Wellington, and Marlborough.
-18. *P. rigidum*
- gg. Shrubs 4 to 6 m. tall; branchlets divaricate, almost spinose; leaves acute to attenuate at base; pedicels minute; flowers 1–3, terminal on short arrested branchlets; sepals 1.2–2.5 mm. long, 0.5–1.0 mm. broad; petals 3.0–7.5 mm. long, 1.0–1.5 mm. broad; ovary tomentulose or glabrous; capsules subglobose, 4.5–7.0 mm. long and broad.
- h. Shrubs to 4 m. tall; main branches usually fastigate; adult leaves (exposed) elliptic-oblong, 3.5–17.0 mm. long, 1–4 mm. broad, entire, (in shade) usually with 1–5 lobes or teeth on each side; flowers 1–3 sepals 1.2–1.5 mm. long, 1 mm. broad; petals 4.0–7.5 mm. long, 1.2–1.5 mm. broad; ovary tomentulose; capsules subglobose to globose, rugose. Marlborough, Nelson, Canterbury, and Westland19. *P. crassicaule*
- hh. Shrubs to 6 m. tall; main branches usually interlaced; adult leaves (exposed) linear-oblancoate to linear-oblong or ovate, 4–10 mm. long, 2–7 mm. broad, entire, occasionally crenate; adult leaves (shade) usually with 1–3 lobes or teeth on each side; flowers solitary; sepals 1.5–2.5 mm. long, 0.5–1.0 mm. broad; petals 4–6 mm. long, 1.0–1.5 mm. broad; ovary glabrous; capsules cordate or subglobose, weakly rugose. Hawkes Bay, Volcanic Plateau, Nelson and Canterbury
-20. *P. divaricatum*
- ee. Shrubs completely prostrate in the open, a tangled mass up to 1 m. tall in shade; flowers solitary, terminal on short arrested branchlets; petals obovate to oblanceolate, variously colored; capsule valves dehiscent in part, leaving a persistent papery endocarp covering the seeds. Volcanic Plateau, Nelson, and Canterbury.21. *P. anomalum*
- bb. Epiphytic shrubs, seldom terrestrial; flowers terminal; petals yellow; capsules ellipsoid. New Zealand.
- c. Slender branched shrub 0.5–1.5 m. tall, polygamous or dioecious; leaves obovate to ovate-elliptic; male flowers about 10; female flowers 1–2; capsules about 1.7 cm. long, 1.2 cm. broad. North Auckland to Marlborough.....22. *P. cornifolium*
- cc. Stoutly branched shrub 1–5 m. tall, monoecious; leaves linear-obovate to oblong-elliptic; flowers 3–10; capsules 2.6–3.9 cm. long, 1.1–1.7 cm. broad. North Auckland to Wanganui23. *P. kirkii*
- aa. Inflorescence cymose.
- b. Capsules without a persistent papery endocarp. Australia.
- c. Flowers few (1–32), and relatively large; sepals 4.0–10.5 mm. long; petals 11–18 mm. long, connate or connivent in a cylindrical or urceolate tube, tips spreading to reflexed; capsules lobed, ellipsoid, or ovoid.
- d. Shrubs 1.5–6 m. tall; leaf margins flat or revolute; sepals slightly imbricate at base; petals yellow; capsules 1.3–2.8 cm. long.
- e. Shrubs to 3 m. tall; branchlets rusty-tomentose when young, glabrescent; leaves 4–19 cm. long, subcoriaceous to coriaceous, with appressed rusty tomentum beneath, acute to shortly acuminate, margins thickened and revolute; bud scales persistent; inflorescence 1- to 11-flowered; sepals sparsely tomentulose to glabrate; capsules 4- to 6-lobed, 2- to 4-valved, 1.5–2.8 cm. long, coarsely rugose, sessile; valves woody, 2–3 mm. thick, placentas bearing funicles from the base to near the apex; seeds 20–76. Queensland, New South Wales and Victoria.24. *P. revolutum*
- ee. Shrubs 1.5–6 m. tall; branchlets rusty-tomentose, not glabrescent; leaves 6.0–33.5 cm. long, membranous with sparse erect red hairs beneath, rusty-tomentose on the veins, acutely acuminate to cuspidate, margins flat, unthickened, sometimes irregularly revolute; bud scales caducous; inflorescence 3- to 32-flowered; sepals tomentose; capsules ellipsoid to ovoid, 2-valved, rarely 3-valved, 1.3–2.1 cm. long, minutely rugose, stipitate; valves coriaceous, under 1 mm. thick; placentas bearing funicles from the base to the middle; seeds 3–14. Queensland.25. *P. rubiginosum*
- dd. Shrubs or trees 5–13 m. tall; leaf margins markedly undulate; sepals frequently connate in a tube splitting into 2 parts, one 1- to 2-lobed, the other 3- to 4-lobed;

- petals white; capsule subglobose, 2-valved, 1.0-1.4 cm. in diameter. Queensland, New South Wales and Victoria.26. *P. undulatum*
- cc. Flowers very numerous and relatively small; sepals 1.1-3.5 mm. long; petals 5.5-9.0 mm. long, connivent in a cylindrical tube, or free and patent; capsules globose to obovoid.
- d. Sepals oblong to ovate, obtuse to acute; capsules subglobose to obovoid, 2-valved, rarely 3-valved, stipitate; valver woody or coriaceous, about 1 mm. thick.
- e. Leaves lanceolate to ovate-lanceolate; sepals oblong, obtuse, rusty-tomentose; capsules subglobose to obovoid, 1-2 cm. long, 2- or rarely 3-valved; valves 1-2 mm. thick, woody, convex in transverse section; placentas much thickened and fused at base, bearing 6-8 funicles about the middle; trees to 10 m. tall; petals white; seeds 6-14, reddish-black to black. Queensland.27. *P. venulosum*
- ee. Leaves oblanceolate, oblong, rhombic, or ovate; sepals ovate, acute to subacute, white-tomentulose or glabrous; capsules obovoid, 2-valved; valves less than 1 mm. thick, woody, usually sulcate in transverse section; placentas much thickened at base and apex and fused more or less completely to form two chambers, bearing several funicles from the base to the middle or at the base.
- f. Shrubs or small trees to 6 m. tall; leaves oblanceolate to oblong, entire; petals yellow; capsules 6-15 mm. in diameter; valves with a placenta bearing several short stout funicles between the base and the middle; seeds 2-6, black. Northern Territory and Northern Queensland28. *P. melanospermum*
- ff. Trees 13-30 m. tall; leaves rhombic to ovate, usually coarsely serrate; petals white; capsules about 5-10 mm. long, 5-8 mm. broad; valves with a placenta bearing 1 or 2 minute funicles near the base; seeds 1-3, black. Queensland and northern New South Wales.29. *P. rhombifolium*
- dd. Sepals linear to linear-lanceolate, acute to acuminate; capsules globose to subglobose, 2-valved, sessile, 7-10 mm. in diameter; valves coriaceous, less than 1 mm. thick, convex in transverse section; placentas with funicles from the base to the middle; seeds about 16, black; trees or shrubs 8-20 m. tall; petals yellow. Queensland and Malay Archipelago.30. *P. ferrugineum*
- bb. Capsules with a persistent papery endocarp. New Zealand.
- c. Trees 4-6 m. tall; leaves coarsely serrate to entire; inflorescences condensed, about 40-flowered; petals white with red veins; capsules about 15 mm. long, 9 mm. broad; placentas bearing about 12 funicles from the base to near the apex. Northwest Nelson.31. *P. dallii*
- cc. Trees 6-13 m. tall; leaves entire; inflorescences spreading, 30- to 70-flowered; petals yellow; capsules 9-10 mm. long, 5-6 mm. broad; placentas bearing 2-4 funicles near the middle. North Auckland to Otago.32. *P. eugenioides*
9. *PITTIOSPORUM PHILLYRAEOIDES* DC. Prodr. 1:347. 1824. (T.: *Leschenault s.n.*!).
- Pittosporum angustifolium* Lodd. Bot. Cab. 19: t. 1859. 1832, ex icon. & char.
- Pittosporum ligustrifolium* A. Cunn. ex Loud. Hort. Brit. Suppl. 1: 597. 1832, nom. nud.
- Pittosporum longifolium* Putterl. Syn. Pittosp. p.15. 1839, ex char. (T.: *Roe s.n.*).
- Pittosporum roeanum* Putterl. loc. cit. p.16. 1839, ex char. (T.: *Roe s.n.*).
- Pittosporum ligustrifolium* A. Cunn. ex Putterl. loc. cit. p. 16. 1839. (T.: *A. Cunningham s.n.* [30, 142] ! Rottneest Is.).
- Pittosporum oleaeifolium* A. Cunn. ex Putterl. loc. cit. p. 17. 1839. (T.: *A. Cunningham s.n.* [31, 32, 143] ! Dick Hartog Is.).
- Pittosporum acacioides* A. Cunn. in Ann. Nat. Hist. 4: 109. 1839. (T.: *R. Brown s.n.* [5447] !).
- Pittosporum salicinum* Lindl. in Mitch. Jour. Exped. Int. Trop. Austr. p. 97. 1848. (T.: *Mitchell* 273 !).
- Pittosporum lanceolatum* A. Cunn. in Mitch. loc. cit. p. 272, 291. 1848, nom. nud.
- Pittosporum phillyraeoides* DC. var. *microcarpa* S. Moore in Jour. Bot. 35: 163. 1897. (T.: *Spencer Moore s.n.* !).

Shrubs to small trees 3-10 m. tall; branches pendulous; branchlets grayish-brown, tomentose when young, soon glabrate. Leaves alternate, linear-oblong to linear-oblanceolate, rarely elliptic-oblong, acute and apiculate at apex, attenuate at base, entire, 2.5 - 12.6 cm. long, 2 - 15 mm. broad, tomentose when young, soon

glabrate, very coriaceous, margins flat or revolute, costa raised to sunken above and below, secondary veins usually obscure; petioles 4 - 15 mm. long, 0.5 - 1.0 mm. broad, glabrous. Flowers pseudoterminal and axillary, 1 - 4, solitary or fascicled, rarely in 3- to 4-flowered cymes, clustered at the ends of leafy branchlets; peduncles and pedicels 3 - 15 mm. long, accrescent in fruit, sparsely tomentulose, glabrate, subtended by a single leaf and a whorl of caducous bud scales 1 - 2 mm. long. Sepals imbricate or coherent at base, 1 - 2 pairs occasionally fused to apex, lanceolate, subacute to acute, 2 - 3 mm. long, 1.1 - 2.0 mm. broad, glabrous; petals linear-oblong to linear-oblongate, sometimes slightly pandurate, obtuse, 8 - 11 mm. long, 2.0 - 3.5 mm. broad, coherent in a cylindrical or somewhat urceolate tube for about two-thirds of their length, tips spreading to reflexed, yellow to white; stamens 4.2 - 8.0 mm. long, anthers sagittiform, ovoid or oblong, 1.0 - 3.3 mm. long, 0.8 - 1.3 mm. broad. Pistil at anthesis slightly shorter or longer than the stamens; ovary 3.0 - 5.5 mm. long, 1 - 3 mm. broad, tomentose, sometimes glabrate above; style 1.5 - 3.0 mm. long; stigma capitate, sometimes obscurely lobed. Capsules ovoid to globose, obtuse to subacute, 2-valved, rarely 3-valved, apiculate, 1 - 2 cm. long, 9.5 - 19.0 mm. broad, glabrate, smooth, dark red or orange without, yellow within; valves convex to sulcate in transverse section, 1.0 - 3.5 mm. thick, woody, with a conspicuous placenta, fused at the base, bearing short stout funicles from the base to above the middle; seeds 4 - 24, red, irregular.

Occurs throughout Australia. Flowers from July to October.

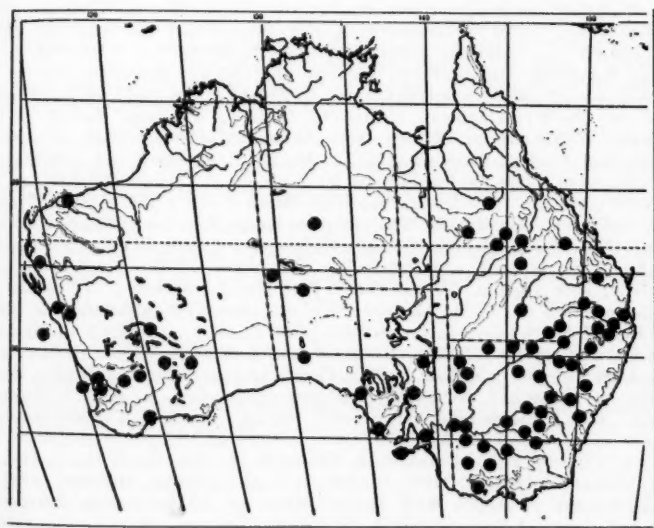


Fig. 14. *P. phyllaroides*.

AUSTRALIA: NORTHERN TERRITORY: 60 miles N.E.C.2. [near Macdonnell Ranges, between Stuart Bluff Range and the Lander], *Hill* 283 (MEL); Northwest Petermann Ranges, *Basedow* 159 (K); Petermann Ranges *Basedow* 171 (K); without locality, *Hill* 98 (NSW). QUEENSLAND: Burdekin, *Mueller s.n.* (K); Hughenden, *Longman s.n.* (A, K); on stony ridges between Aramac and Muttaborra, *Brass & White* 44 (A, K); between Bowen Downs and Mueller's Range, *Birch s.n.* (MEL); Texas, *Boorman s.n.* (A); Mitchell, *Edwards s.n.* (A); Barcoo, *Schneider s.n.* (MEL); Eidsvold, *Bancroft s.n.* (A); in red-brown fine sand, Glenber, C. 40 miles S.E. Charlesville, Warrego District, *Everist* 3397 (K); Barunga, north of Miles, *Belson s.n.* (A); in brigalow scrub in heavy soil, C. 890', Wandoan, *Hubbard* 5024 (K); Wallumbilla, *Francis s.n.* (A, K); Dalby, *White* 9032 (A, K); Moreton Bay, *Mallard s.n.* (GH); Ipswich, *Nernst* 35 (MEL); Bumble Station, 70 miles north of Mungindi, *Cabbage* 4404 (NSW); 558', in heavy black soil in open *Eucalyptus* forest, Dirranbandi, *Hubbard* 5572 (A, K); Noondoo, Maranoa District, *Everist* 786 (A, K); apparently epiphytic in an *Eucalypt* (*E. corymbosa*?) near Warwick, *E. Thomson* 16 (K); Silverwood, *White* 1712 (A); Inglewood, *Boorman s.n.* (NSW); Goondiwindi, *Colclough s.n.* (K). NEW SOUTH WALES: Moru-Mungundi District, *Kerry s.n.* (NSW); Uriseno-Thurloo Downs, *Boorman s.n.* (NSW); Middle Warrego, *Bullock s.n.* (MEL); between 40 and 50 miles N.W. of Collarenebri, *Jackson s.n.* (NSW); Bingara, *Boorman s.n.* (BISH); New Angledool, *Paddison s.n.* (A); Narrabi W., *Boorman s.n.* (NSW); same locality, *Lyne s.n.* (NSW); plains country north of the Namoi River, *Taylor s.n.* (NSW); Pilliga, *Rupp s.n.* (NSW); roadside, Baradine, *Lamont* 201 (BM); Bogan River District, *without collector s.n.* (NSW); Castlereagh, *Woolfs s.n.* (MEL); Nyngan Exp. Farm, *Downing s.n.* (BISH, NSW, US); Cobbora-Boomley Rd., 1700', on quartzite in rocky scrub-land, *Johnson & Constable s.n.* (NSW); Currabubula, *Cabbage* 3575 (NSW); Cobar, *Hadley s.n.* (NSW); Trangie, *Maclean* 6 (NSW); Barrier Range, *Irvine s.n.* (BM, MO); Broken Hill, *Morris s.n.* (NSW); in open plain, Mundi Mundi Station, Broken Hill, *Constable s.n.* (NSW); sandy flat, Wilmatha, Condobolin, *Hadley* 29 (A, NSW); Wyalong, *Boorman s.n.* (NSW); same locality, *House s.n.* (K, MO); Wollongong, *Wilkes s.n.* (US); E. Mirrool, *Campbell s.n.* (NSW); in barren country S.W. of the Lachlan River, *A. Cunningham* 35 (K); in granite soil at side of road, Ardlethan District, *Constable s.n.* (AK, K, NSW, US); Temona, *Dwyer s.n.* (MO, NSW); junction of Darling and Murray rivers, *Holding s.n.* (MEL); Wagga, *Helms s.n.* (NSW); Yenda, *Searcy s.n.* (NSW); without definite locality, *Fraser s.n.* (A, K); VICTORIA: Mildura, *Limmer s.n.* (UMEL); Lower Murray River, *Mueller s.n.* (BM, GH, K, MO); Box Ridge, Robinvale, Murray River, *Froggatt s.n.* (NSW); Benjeroop, Murray River, *C. French Jr. s.n.* (NSW); Swan Hill District, *C. French Jr. s.n.* (GH, MEL); Deniliquin, *Crawford s.n.* (NSW); Dimboola, *d'Alton* 31 (NSW); Wimmera, *Mueller* 18 (GH); same locality, *Williamson s.n.* (NSW); same locality, *Walter s.n.* (GH, NSW); scrub, Kamarooka, near Bendigo, *Paton s.n.* (MEL); Mallee, *C. French Jr. s.n.* (NSW); ranges bearing S.W. from Camp 29 [vicinity of Mt. Cole, near Ararat], *Mitchell s.n.* (BM). SOUTH AUSTRALIA: Gov. Northwest Expedition, *Basedow* 112 (NSW); Elder Expedition, Camp 10, *Helms s.n.* (K, MEL, NSW); Musgrave Range, *Lord s.n.* (MEL); Ooldea, *Kershaw s.n.* (MEL); Commonwealth Hill, near Ooldea, *Basedow* 84 (NSW); Mt. Lyndhurst, *Koch* 7 (K); Flagstaff Point, near Streaky Bay, *Rogers s.n.* (NSW); Streaky Bay, *Crocker s.n.* (CANB); Port Augusta, *Lea s.n.* (BM); Port Lincoln, *Browne* C. 29 (MEL); same locality, *Schomburgk s.n.* (US); Memory Cove, near Port Lincoln, *Maiden s.n.* (NSW); shores of Bay III, South Coast, *R. Brown* 5447 (BM, K, MO); 10 miles E. of Mannum, in mallee scrub, *Vickery s.n.* (NSW); Kangaroo Island, *Waterhouse s.n.* (MEL); Central Australia, *Sturt s.n.* (BM); without locality, *Conservator of Forest s.n.* (NSW); WESTERN AUSTRALIA: in stream-bed, Nickol Bay, *Gregory Expedition s.n.* (MEL); Sharks Bay, *Mueller s.n.* (MEL); barren sandy downs, Dirk Hartog's Island, *A. Cunningham s.n.*, 31 32 (K), 143 (BM); Murchison River, *Oldfield s.n.* (GH, K, MEL); Greenough Flat, *Gray s.n.* (MEL); Tabletop Hill, Northampton, *Campbell* 18 (K); South Island, Houtman's Abrothos, *Gilbert* 98 (BM, K, MO); Walkaway, S. of Geraldton, *Morrison* 13305 (K); saltbush plain south of Doyle's Well, *Spencer Moore s.n.* (BM); Arrino, *Fitzgerald s.n.* (NSW); arid shores of Rottnest Island, *A. Cunningham s.n.*, 30 (K), 142 (BM); in

arenosis sylvae orae occidentalis insulae Rottneest, Preiss 1297 (GH, MO, P); Swan River, *Drummond s.n.* (K), 31 (BM, K, MO); 57, 76 (K), 76 (BM); R. des Cygnes, *Drummond 76* (P); same locality, *Preiss 1297* (P); limestone rocks, face of cliff, Claremont, *Andrews 37* (BM, K); Kellerberrin, *Vachell s.n.* (NSW); Merredim, *Koch 2983* (K, MEL, NSW); near rock outcrop about 6 miles N.W. of Muntadgin, *Bailey 182* (CANB); 70 miles N. of Coolgardie, *C. A. White s.n.* (K); Main Camp, Kurrawang, *Maiden s.n.* (NSW); E. of Kalgoorlie, Transcont. Ry. Survey, *Deans s.n.* (NSW); Point Peron, on sand dunes near sea, *Burbidge 1962* (CANB); on damp flat in plain, 7 miles west of Deakin, *Calaby s.n.* (CANB); Benner Bay, *Menzel 56* (NSW); without definite locality, *Drummond 76* (MO). WITHOUT LOCALITY: Exped. Faudin, *Leschenault s.n.* (BM); N. Holl., *Lhotsky s.n.* (P); *Mitchell s.n.*, 228, 229, 273 (K); [228, 229, on the Belyando River near $147^{\circ} \times 22^{\circ}$, 27', Mantuan Downs between Kilsyth and valley of Nogoia River $147\frac{1}{2}^{\circ} \times 24\frac{1}{2}^{\circ}$.]

Flowers which may be female have pistils slightly longer than the stamens, large capitate stigmas, styles about 1.5 mm. long, ovaries 4.0 - 5.5 mm. long, 2.5 - 3.0 mm. broad, and sagittiform to ovate anthers 1.0 - 1.5 mm. long, borne on filaments only 3 - 4 mm. long. Flowers which may be male have pistils slightly shorter than the stamens, smaller capitate stigmas, styles 3.0 - 3.5 mm. long, ovaries 3 - 4 mm. long, 1 - 2 mm. broad, and oblong anthers 2.0 - 3.3 mm. long borne on filaments 3.5 - 6.0 mm. long. Intermediate forms with large anthers and plump ovaries occur.

Pittosporum phillyraeoides is grown as a hedge, windbreak, and as an ornamental shrub in the United States (California, Arizona, and Florida), France, Australia, and New Zealand; and in the drier parts of Australia it is used as a stock food.

The variability of the leaves was noted by Bentham¹⁵⁰, who commented:

This species, apparently spread over the whole desert country of Australia, cannot be confounded with any other notwithstanding the variability of the proportions of its leaves, flowers and fruit. In some of the western specimens the leaves are barely 2 inches long, and fully an inch wide, whilst in a large number of eastern and some western ones they attain 4 or 5 inches in length with a breadth of only 2 or 3 lines.

In the material I have examined there is a specimen from Shark Bay, western Australia (*Mueller s.n.* MEL), with elliptic-oblong leaves about 3.5 cm. long and up to 1.7 cm. broad, covered with appressed tomentum beneath, but this extreme is connected with the more common form by a number of intermediates, and I am unable to define any varieties. The variability of the capsules in size and shape must be mentioned. Again the extremes are connected by intermediates and I am unable to recognize var. *microcarpa* S. Moore.

Vernacular names: Butter Bush, Willow or Willow Tree, *Berrigan*, Locket Bush, Butterwood, Bell's Orange, Quinine Tree, Weeping Pittosporum, Native Willow, Poison-berry Tree, Apricot Tree, West Australian Willow, *Macla* (Paroo River Blacks), *Derrine* (Dubbo Blacks).

¹⁵⁰ Fl. Austr. 1: 113. 1863.

10. *PITTIOSPORUM BICOLOR* Hook. in Jour. Bot. 1: 249. 1834. (T.: Lawrence s.n.).

Pittosporum huegelianum Putterl. in Endl. Nov. Stirp. Dec. 43. 1839, ex char. (T.: Hügel s.n.).

Pittosporum discolor Regel in Gartenflora 1:133. t. 15. 1852, ex icon.

Shrubs to small trees 3 - 16 m. tall; branchlets ascending; branchlets grayish-brown, the young parts hoary or rusty-tomentose, soon glabrous. Leaves alternate, rarely subverticillate, oblong-lanceolate to linear, obtuse or apiculate at apex, acute or attenuate at base, entire, 2 - 7 cm. long, 3 - 18 mm. broad, glaucous-green and glabrous above, white-, yellow- to brown-tomentose beneath, coriaceous, revolute, costa and secondary nerves usually distinct above, costa distinct beneath, but secondary nerves obscure; petioles 2-5 mm. long, 1-2 mm. broad, tomentulose when young. Flowers pseudoterminal and axillary, 1 - 4, solitary or fascicled, clustered at the ends of leafy branchlets; pedicels 3 - 19 mm. long, accrescent in fruit, brown-tomentose, subtended by numerous caducous bud scales about 1 mm. long. Sepals imbricate at base, lanceolate, acute, 2-6 mm. long, 1-3 mm. broad, puberulous; petals lanceolate-oblong, subacute, 9 - 15 mm. long, 2 - 4 mm. broad, free or coherent at the base, spreading from above the middle, yellow with red veins, yellow marked with red, or reddish purple; stamens 3 - 9 mm. long, anthers elliptic-oblong, 1 - 3 mm. long, 0.5 - 1.0 mm. broad. Pistil at anthesis as long as the stamens, rarely almost twice as long; ovary 3 - 5 mm. long, 2 - 3 mm. broad, villous; style 1.5 - 5.0 mm. long; stigma capitate and obscurely 4-lobed on short-styled pistils, weakly capitate to truncate on long-styled pistils. Capsules subglobose, 2-valved, rarely 3-valved, 7 - 13 mm. in diameter, tomentose, glabrate; valves convex in transverse section, less than 1 mm. thick, coriaceous, with a conspicuous placenta bearing short stout funicles from the base to just above the middle; seeds 10 - 20, yellowish-red to reddish-black, irregular.

Fairly common from sea-level to 1300 m. in Tasmania, less common in eastern Victoria and southern New South Wales. Flowers from July to December.

AUSTRALIA: NEW SOUTH WALES: Bibbenluke, near Bombala, *Edwards s.n.* (NSW); Glenbog State Forest, *Beuzeville LI* (NSW); Brown Mountains near Littleton, *Betche s.n.* (NSW). VICTORIA: Sherbrook Forest, *Lothian s.n.* (GH); Blacks Spur, *Deane s.n.* (BISH, NSW); same locality, *Morris 1441* (NSW); Milla Milla, *Clinton s.n.* (NSW); Bonang, *Baeunton s.n.* (NSW); near Mt. Ellery, *Merrah s.n.* (MEL, NSW); Genoa District, *Baeunton s.n.* (MEL, NSW); along Dividing Range, *Stirling s.n.* (NSW); same locality, *Walter s.n.* (BISH, NSW); Matlock, *Staer s.n.* (NSW); Upper Yarra, *Staer s.n.* (NSW); Mt. Baw Baw, *C. French Jr. s.n.* (MEL, NSW); same locality, *Walter s.n.* (NSW); Mt. Disappointment and Dandenong, *Mueller s.n.* (MEL, NSW); near Melbourne, *Cecil 219* (K); Ferntree Gully, *Staer s.n.* (NSW); Emerald, *Rendle s.n.* (BM); Paradise, *Cookson s.n.* (UMEL); Korumburra, *Baker s.n.* (MEL); East Gippsland, *C. French Jr. s.n.* (GH); same locality, *Mueller s.n.* (US); same locality, *Stirling s.n.* (BM); Corner Inlet, *Mueller s.n.* (NSW); Sealer's Cove, *King s.n.* (BM, K, NSW); near Cape Otway, *Lucas s.n.* (MEL, NSW). TASMANIA: King's Island, *Seyer s.n.* (MEL, NSW); Circular Head, *Gunn 154* (K, MO, NSW), *154/1842* (BM); Penguin, *Gunn 154* (NSW); Port Dalrymple, *Paterson s.n.* (BM); Hampshire Hills, [*Gunn*] *s.n.* (K); same locality, *Milligan s.n.* (HO); Chilton, Surrey Hills, *Gunn s.n.* (K); May Day Plains, 3000-3500', in exposed open situations on the sides or tops of mountains, [*Gunn*] *651* (K); gum forest association, 2700', Dove Valley, *Weindorfer s.n.* (K); Marlborough, *Gunn s.n.* (NSW); Derby to St.

Helens, *Ford s.n.* (NSW); near St. Patrick's River, *Mueller IL19* (MEL, NSW); same locality, *Gunn 154* (NSW); top of Western Mts., 3500', *Gunn 651* (K); Launceston, *Gunn 154* (MO); same locality, *Gunn 154/1842* (BM, K); same locality, *Stuart s.n.* (MEL, NSW); Cataract Gorge, *Rupp 31* (NSW); Cora Linn, N. Esk, *Gunn 154/1842* (NSW); sides of mountains among rocks, [*Gunn*] 650 (K); Arthur's Lakes, *Gunn 651* (K, NSW); sheltered side of beach, Bicheno, *Ford s.n.* (NSW); Macquarie Harbour, *Le Grand s.n.* (MEL); same locality, in damp shaded woods on the low shores, *A. Cunningham 33* (K); beech forest between Lake Huegel and Lake St. Clair, *Burbidge 3359* (CANB); 3500', Lake Fenton National Park, *Lord s.n.* (HO, K); rocky slopes above Lake Fenton, Mt. Field National Park, *Burbidge 3280* (CANB); Maria Island, summit of mountain, c. 2000', *Gibbs 6395* (K); Hobart Town, *Siemsen s.n.* (MEL, NSW); Lenah valley near Hobart, *White 8406* (A, BM); prope Derwent, *Brown 5448* (BM, K, MO); Diabase Hill, Collins Vale in Fairy Glen, *Long 1008* (HO); open places in moist forest, 2000', Collinsvale, *Comber 1550* (K); 300', Waterworks, Hobart, *Olsen s.n.* (HO); 800', near waterworks, *Atkinson 93* (CANB, HO, K); 1000', High Peak, Hobart, *Curtis s.n.* (BH); rocky hillside above springs, Mt. Wellington, *Long 355* (HO); Mt. Wellington, *Gunn 154/1842* (NSW), 651/1842 (BM); same locality, *Verreaux 1961* (K, P); same locality, *Maiden & Cambage s.n.* (NSW); 1200', by creek bank, New Town side, Mt. Wellington, *Long 375* (HO, K); 3000', above springs, Mt. Wellington, *Long 355* (A); Kangaroo Bottom, *Hooker 844* (K); Sassafras Valley, *Hooker 842* (K); Mt. Nelson, *Rodway s.n.* (HO); Little Plain, *Simson s.n.* (AK); Adventure Bay, [*Bligh, Wiles & Smith*] *s.n.* (BM, K); Recherche Bay, *Maiden 3991* (BH, NSW). WITHOUT LOCALITY: *Archer s.n.* (NSW); *Blyth s.n.* (NSW); *Caley s.n.* (A); *Gunn 154, 651* (GH, K); *Hannaford s.n.* (NSW); *La Billardiére s.n.* (BM, GH, MO); *Lawrence s.n.* (K).

The variation in plant form and leaf size in this species was noticed by Hooker¹⁰⁰, who remarked:

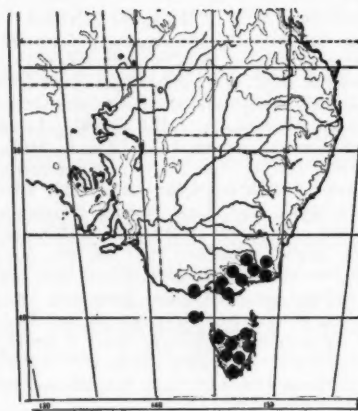
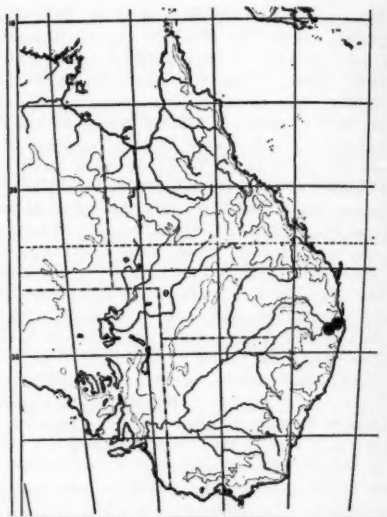
One of the most variable plants in the Island (Tasmania), forming in low grounds, a tree 30 - 40 feet high; with a trunk a foot and more in diameter, but gradually becoming a stunted scrubby bush on ascending the mountains. The changes of habit and characters on ascending are so gradual that I cannot rigidly define the varieties, of which the following are the best marked; on low ground, branches lax, twiggy, with spreading flat, linear-obovate or oblong leaves, 1-2 inches long, with slightly revolute margins and silvery grey down beneath; on ascending, the branches become short, rigid, robust, erect, leaves densely crowded, erect, shorter, blunter, with rigidly coriaceous margins very revolute, clothed below with ferrugineous silky and villous hairs.

The flowers also vary in size and form. Flowers which may be female have capitate stigmas, styles 1 - 2 mm. long, plump ovaries, filaments 2 - 3 mm. long, and possibly abortive anthers about 1 mm. long. Flowers which may be male have weakly capitate to truncate stigmas, styles 3 - 5 mm. long, slender ovaries, filaments 3 - 5 mm. long, and functional anthers 2 - 3 mm. long. Pedicels of female flowers are usually shorter than those of male flowers. Between the two extremes described, intermediate forms have been found; e.g. *Lord s.n.* from 3500' at Lake Fenton National Park has a truncate stigma, style 3 mm. long, filaments 4.5 - 5.0 mm. long (i.e. it appears to have male flowers) but the anthers are only 1 mm. long, apparently abortive; *Olsen s.n.* from 300' at the waterworks, Hobart, has a capitate stigma, style 1.5 mm. long, and anthers 1.5 mm. long (i.e. it appears to have female flowers) but the filaments are 4.5 mm. long as in male flowers.

Pittosporum bicolor is cultivated in California and England.

Vernacular names: Whitewood, Tallow-wood, Tolosa-wood, Dragon's Blood Pittosporum (Tasmania), Cheesewood (Victoria), *Banyalla* (Victoria, aboriginal).

¹⁰⁰ Fl. Tasman. p. 38.. 1860.

Fig. 15. *P. bicolor*.Fig. 16. *P. o'reillyanum*.

11. *PITTOSPORUM O'REILLYANUM* White, in *Proc. Roy. Soc. Queensland* 47:53. 1936. (T.: White 6173!).

Shrubs 1 - 2 m. tall; branchlets grayish-brown, spinose, brown-tomentulose when young, soon glabrate. Leaves alternate, sometimes clustered on arrested branchlets, ovate to elliptic-oblong, acute to cuspidate at apex, obtuse at base, entire, 2.5 - 20.0 mm. long, 2 - 5 mm. broad, green above, paler beneath, sparsely tomentulose when young, soon glabrate, margins flat or recurved, costa immersed above and beneath, secondary nerves 2 - 4 per side, anastomosing, distinct or obscure; petioles up to 1.0 mm. long, sparsely tomentulose when young, soon glabrate. Flowers axillary or terminal, on arrested branchlets, solitary; pedicels 1 - 2 mm. long, accrescent in fruit, brown-tomentose, subtended by 1 to several leaves and caducous brown-tomentose bud scales 0.5 - 1.0 mm. long. Sepals irregularly connivent at the base, subulate, acute, 1.7 - 2.0 mm. long, 0.5 - 0.8 mm. broad, tomentulose; petals linear to linear-oblancoelate, subacute to acute, 6.0 - 9.5 mm. long, 1.2 - 1.5 mm. broad, connivent in a cylindrical or slightly spreading tube with reflexed tips; stamens 6.8 - 7.0 mm. long, anthers oblong to ovate, 1.8 - 2.0 mm. long, 0.7 - 1.0 mm. broad, filaments filiform, coherent to the petals. Pistil at anthesis equal to the stamens; ovary 3 - 4 mm. long, 1 mm. broad, tomentulose; style 2.5 - 3.0 mm. long; stigma subcapitate, obscurely 2-lobed. Capsules globose, 2-valved, apiculate, 7 - 12 mm. broad, glabrous, smooth; valves convex in transverse section, less than 1 mm. thick, coriaceous, with a placenta bearing 3 - 4 strap-like funicles, up to 2 mm. long, from the middle to the base; seeds about 6, light red, irregular.

Occurs at high altitudes in southeast Queensland. Flowers in September and October.

AUSTRALIA: QUEENSLAND: very common in rain forest, usually weighted down with masses of liverworts and mosses, 4000', Mt. Hobwee, Lamington National Park, *White* 6173 (A, BM, K, MO); in *Nothofagus* forest, 3700', Mt. Merino, MacPherson Range, *Johnson s.n.* (NSW); MacPherson Range, *Perry* 512 (CANB).

12. *PITTOSPORUM UMBELLATUM* Banks & Soland. ex Gaertn. Fruct. et Sem. 1: 286. *t.* 59. 1787-88. (T.: *Banks & Solander s.n.*!).

Pittosporoides umbellata Soland. ex Gaertn. loc. cit. 1787-88, *nom. nud. in synonym.*

Small trees 4 - 10 m. tall; branchlets grayish-brown, the young parts sparsely brown-tomentose when young, soon glabrate. Leaves subverticillate, dark green above, paler beneath, glabrous, coriaceous, margins thin, flat and brown-pilose when young, thickened, revolute, and glabrate when mature, costa raised above and beneath, frequently sparsely brown- to white-tomentose at base, secondary veins 8 - 15 per side, anastomosing, obscure above, distinct beneath. Juvenile leaves obovate to oblanceolate, usually crenate, lobed, or parted; adult leaves elliptic to oblong-lanceolate, entire, or rarely crenate, acute or acuminate at apex, acute to attenuate at base, 2.5 - 10.0 cm. long, 1.5 - 5.0 cm. broad; petioles 6 - 22 mm. long 1 - 2 mm. broad, brown-tomentose when young, glabrate. Inflorescences terminal or sometimes becoming lateral on development of a leading shoot from an axillary bud, in umbels up to 20-flowered; pedicels 4 - 25 mm. long, accrescent in fruit, brown-tomentose, subtended by an approximate whorl of leaves and numerous caducous, glabrous, ciliate bud scales up to 12 mm. long. Sepals slightly imbricate at base, lanceolate, acute to acuminate, 4.5 - 9.0 mm. long, 1.5 - 3.0 mm. broad, sparsely ciliate; petals linear-oblong, subacute to obtuse, 11.0 - 12.5 mm. long, 2.5 - 5.0 mm. broad, loosely coherent at the base, spreading from above the middle, dull red; stamens 4 - 8 mm. long, anthers sagittiform to elliptic-oblong, 1 - 3 mm. long, 0.6 - 1.3 mm. broad. Pistil at anthesis slightly shorter or longer than the stamens; ovary 2.5 - 3.5 mm. long, 1 - 3 mm. broad, villous; style 3 - 4 mm. long; stigma capitate and obscurely 4-lobed, or truncate. Capsules tetragonous or 4-lobed, 2-valved, 7 - 12 mm. in diameter, green to black, sparsely pubescent; valves concave in transverse section, less than 1 mm. thick, with much thickened rims, coriaceous, with a conspicuous placenta bearing short stout funicles from near the base to just above the middle; seeds 9 - 14, black, irregular.

Occasional from the North Cape to the Coromandel Peninsula, North Island of New Zealand, in forest remnants on the sea coast and coastal islands. Reputed to occur as far south as Gisborne in Poverty Bay, but I have not seen specimens from south of the Thames district.

NEW ZEALAND: NORTH AUCKLAND: summit of Ounuwahao, 950', Spirit's Bay, *Cooper* 24478 (AK); at waterfall, near sea-level, Kapowairua valley, Spirit's Bay, *Cooper* 24448 (AK); Spirit's Bay, *Cheeseman s.n.* (AK); at sea-level, Taipa, base of Doubtless Bay, *Walker* 5364 (AK, MO, US); in *Agathis australis* forest, Saies, Whangaroa Harbour, *Cooper* 35960 (AK, MASS, MO); Totara North, Whangaroa Harbour, *Carse s.n.* (AK); Koukoumiko, Baie des Iles, *Raoul s.n.* (P), 81 (K); Bay of Islands, *Wilkes s.n.* (US);

same locality, *A. Cunningham* 29/1826 (K); same locality, *Fraser s.n.* (K); same locality and Tippona, *Wilkes s.n.* (K); Opua, Bay of Islands, *Moore & Cranwell s.n.* (AK); Helena Bay, *Olsen s.n.* (AK); Whangarei Heads, *Cheeseman s.n.* (AK, GH, NSW); same locality, *Baylis s.n.* (K); same locality, *Turner s.n.* (AK); same locality, *Turbott s.n.* (AK); Taranga (Hen Island), *Moore & Cranwell s.n.* (AK). THAMES: Great Barrier Island, *Kirk s.n.* (AK), 90 (K); same locality, *Hynes s.n.* (AK); same locality, near State forest Service Station, *Lloyd & Anderson* 36309, 36310 (AK); same locality, coastal forest, Whangapara, *Molesworth s.n.* (AK); Little Barrier Island, *Kirk* 90 (K); same locality, *Cheeseman s.n.* (AK, US); same locality, *Shakespeare s.n.* (AK); same locality, *Adams s.n.* (AK); same locality, 1000', *Turner s.n.* (AK); Cape Colville, *Kirk s.n.* (AK); Te Mochau, near Stony Bay, c. 1000 - 1100', *Moore & Cranwell s.n.* (AK, K); Shag Bay, Coromandel Peninsula, *Moore & Cranwell s.n.* (AK, K); Coromandel, sea-level, *Mackie s.n.* (AK); Kennedy Bay, *Matthews s.n.* (AK); in sylvis prope Opuragi, *Banks & Solander s.n.* (BM); Mercury Bay, *Kirk* 6 (A, BM, GH, MO, US); North of Buffalo Beach, *Whetter* 1980 (AK); Tapu, Thames Coast, *Molesworth s.n.* (AK); Thames, *Cheeseman s.n.* (AK); same locality, *Adams s.n.* (AK); same locality, near sea, *Petrie s.n.* (A). WITHOUT LOCALITY: *Banks & Solander s.n.* (AK, MO, US); *Colenso s.n.* (K); *A. Cunningham* 30 (U); *R. Cunningham* 192, 613 (K); *Hooker*, 350, 351 (K); *Kirk s.n.* (K); *Wilkes s.n.* (GH).

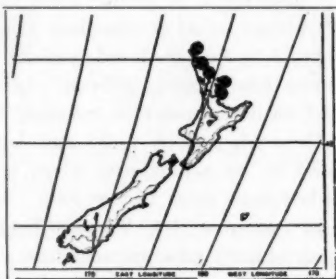


Fig. 17. *P. umbellatum*.

Heterophylly in this species has been described and illustrated in the discussion of taxonomic criteria. Flowers occur which are probably female. They have capitate, 4-lobed stigmas which are exserted 1 - 2 mm. beyond the stamens, and sagittiform anthers only 1.0 - 1.5 mm. long, which appear to be abortive. The pedicels are usually short (4 - 14 mm.). Flowers which are perhaps male have truncate stigmas, styles 1.0 - 1.5 mm. shorter than the stamens, elliptic-oblong anthers 2 - 3 mm. long, and ovaries which are slender and appear to be abortive. The pedicels are usually long (10 - 25 mm.). Intermediate forms occur with weakly capitate stigmas and pistils which are more or less equal in length to the stamens. I have not found flowers with capitate and truncate stigmas in the same inflorescence, or on the same specimen, but field studies are required to determine the significance of these morphological differences.

A form of the species having leaves gradually narrowed below and cordate capsules has been described as *P. umbellatum* var. *cordatum* by Kirk in N.Z. Inst. Trans. & Proc. 4: 264. 1872. (T.: *Kirk s.n.* A, AK, GH, MO, 90K.) The original

specimens came from the Great and Little Barrier Islands where there are several puzzling forms, and until further studies are made of these populations the status of the variety is obscure.

A cultivated specimen from the Scilly Islands has been seen, *Hill s.n.* (K).

Vernacular name: *Haekaro*.

13. *PITTOSPORUM VIRGATUM* Kirk, in N.Z. Inst. Trans. & Proc. 4: 264. 1872. (T.: Kirk s.n.!).

Pittosporum virgatum var. *crataegifolia* Kirk, loc. cit. 265. 1872. (T.: Kirk s.n.!).

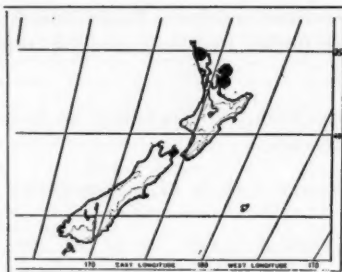
Pittosporum virgatum var. *serratum* Kirk, loc. cit. 1872. (T.: Kirk s.n.!).

Pittosporum virgatum var. *sinuatum* Kirk, Students' Fl. N.Z. p.51. 1899. (T.: Kirk s.n.!).

Pittosporum matthewsii Petrie, in N.Z. Inst. Trans. & Proc. 52: 17. 1920. (T.: Matthews s.n.!).

Small trees to 8 m. tall; branchlets brown, rusty-tomentose when young, soon glabrate. Leaves alternate, frequently somewhat crowded at the tips of the branchlets; juvenile or lower leaves linear, entire or variously lobed or parted, 1.0 - 3.8 cm. long, 1 - 7 mm. broad, rusty-tomentose, glabrate; intermediate leaves lanceolate to oblong or obovate, usually lobed or parted, 1.3 - 5.2 cm. long, 0.9 - 2.7 cm. broad; adult or upper leaves oblong, occasionally linear, oblanceolate, or elliptic-oblong, entire, rarely sinuate or lobed, 1.8 - 7.0 cm. long, 0.4 - 2.1 cm. broad; margins flat to slightly undulate, sometimes a little thickened and revolute, costa immersed above, raised beneath, tomentose, secondary veins 7 - 9 per side, anastomosing, obscure above, distinct beneath; petioles 1 - 7 mm. long, 0.5 - 1.0 mm. broad. Flowers terminal, 1 - 6, fascicled or solitary; pedicels 5 - 9 mm. long, accrescent in fruit, rusty-tomentose, subtended by an approximate whorl of leaves and several minute rusty-tomentose caducous scales. Sepals not imbricate at base, oblong to linear-lanceolate, acute, 3.5 - 6.5 mm. long, 1.0 - 2.5 mm. broad, rusty-tomentose; petals linear-oblong to linear-oblong, acute, 6 - 13 mm. long, 2 - 3 mm. broad, coherent in a tube to above the middle, tips reflexed, dark red to purple, rarely yellow, pink or white; stamens 4 - 7 mm. long, anthers sagittiform or oblong-ovate, 1 - 2 mm. long, 0.4 - 1.0 mm. broad. Pistil at anthesis equal to or slightly longer than the stamens; ovary 2 - 4 mm. long, 1.0 - 2.5 mm. broad, rusty-tomentose; style 1 - 5 mm. long; stigma capitate and obscurely 2- or 4-lobed on short-styled pistils, truncate on long-styled pistils. Capsules subglobose to subpyriform, 2-, rarely 3-, valved, apiculate, 11 - 16 mm. long, 10 - 13 mm. broad, rusty-tomentose to glabrate, obscurely rugose; valves sulcate to convex in transverse section, about 1 mm. thick, coriaceous, with a thickened placenta bearing stout flattened funicles up to 2.5 mm. long from the base to above the middle or apex; seeds 1 - 16, black, irregular.

Occurs from the hills behind Ahipara on the west coast to Coromandel Peninsula on the east coast of the North Island of New Zealand. Flowers in September and October.

Fig. 18. *P. virgatum*.

NEW ZEALAND: NORTH AUCKLAND: Kaitaia, *Matthews s.n.* (AK, MO); Taumata Mahoe, near Kaitaia, *Matthews s.n.* (AK); range west of Okahu, Kaitaia, *Matthews s.n.* (AK); at edge of forest, high country, Pukepoto, *Matthews & Carse s.n.* (AK); Whangaroa, *Kirk 96* (K). THAMES: Great Barrier Island, *Kirk s.n.* (GH), 521 (BM); same locality, *Kirk 521* (US); same locality, *Matthews & Petrie s.n.* (AK); same locality, *Hynes 26568* (AK); Port Fitzroy, Great Barrier Island, *Kirk s.n.* (AK), 87, 88 (K); back of Whangaraparapara, *Molesworth 22171* (AK); Coromandel, *Cheeseman s.n.* (AK, BISH, GH, NSW); Kennedy Bay, Coromandel, *Matthews s.n.* (AK, MO); Waipuna, Kennedy Bay, *Matthews s.n.* (AK); between Kennedy Bay and Cape Colville, *Matthews s.n.* (AK).

The plants recognized by Kirk as var. *crataegifolia*, var. *serratum* and var. *sinuatum* are juvenile forms. The distinguishing characters of *P. matthewsii* from Kennedy Bay were stated to be the smaller and narrower linear-oblong leaves and the subpyriform capsules. Among the large collection left by Matthews are specimens of *P. virgatum* from both Kaitaia and Kennedy Bay with subpyriform capsules; and Michie has sent me material from the Kaitaia area with linear leaves which match those of *P. matthewsii*, collected at Kennedy Bay (the type locality). As the morphological differences are slight and both of the main populations show them I have not recognized *P. matthewsii* as a distinct population.

The flowers are of two kinds. Flowers which may be female have capitate, 2- or 4-lobed stigmas, styles 1.0 - 2.5 mm. long, ovaries about 4 mm. long and 2.5 mm. broad, short stamens 4 - 5 mm. long, with sagittiform, possibly abortive anthers about 1 mm. long. Flowers which may be male have truncate stigmas, styles 3.5 - 5.0 mm. long, ovaries 2.0 - 3.5 mm. long, 1 - 2 mm. broad, stamens 5 - 7 mm. long with oblong-ovoid, apparently functional anthers 1 - 2 mm. long.

14. *PITTOSPORUM PIMELEOIDES* R. Cunn. ex A. Cunn. in Ann. Nat. Hist. 4: 108. 1839. (T.: R. Cunningham 40, 618!).

Shrubs 0.5 - 2.0 tall, erect or prostrate; branchlets slender, brown, the young parts white or brown-tomentulose, soon glabrous. Leaves alternate, sometimes subverticillate, elliptic, elliptic-obovate, oblanceolate, linear-oblong, or linear, acuminate to obtuse at apex, acute to attenuate at base, entire or obscurely crenulate, 0.5 - 4.3 cm. long, 0.5 - 13.0 mm. broad, pale green above, lighter beneath, sparsely tomentulose and ciliolate when young, coriaceous, margins thickened, flat,

costa raised above and beneath, secondary veins anastomosing to form large areoles, obscure above, obscure or distinct beneath, sessile or with petioles up to 0.5 mm. long. Flowers terminal or sometimes becoming lateral on development of a leading shoot from an axillary bud; male flowers 6-9, fascicled; female flowers solitary; pedicels filiform, 2-9 mm. long, accrescent in fruit, puberulent, subtended by an approximate whorl of leaves and several caducous, glabrous, ciliolate bud scales 2-3 mm. long. Sepals not imbricate at base, linear, acuminate, 2.5-5.0 mm. long, 0.5-1.0 mm. broad, glabrous; petals linear, acuminate, 7.5-11.5 mm. long, 1.0-2.2 mm. broad, coherent in a tube to about their middle, spreading to reflexed above, cream to yellow with a central red stripe; stamens 2.5-6.5 mm. long, anthers sagittiform, or ovate to oblong, 0.5-2.0 mm. long, 0.2-0.8 mm. broad. Pistil at anthesis equal to or slightly longer than the stamens; ovary 1-2 mm. long, 1.0-1.5 mm. broad, villous; style 1.5-3.5 mm. long; stigma capitate and obscurely 2-lobed, or almost truncate. Capsules ovoid, 2-valved, acuminate, 6-12 mm. long, 4-6 mm. broad, green to brown, rugose, pubescent when young, glabrate; valves convex in transverse section, less than 1 mm. thick, coriaceous, with a slightly thickened placenta bearing flattened funicles up to 3 mm. long from base to near the middle; seeds 7-17, black, irregular.

KEY TO THE SUBSPECIES

Shrubs usually erect, 0.5-2.0 m. tall; leaves oblanceolate, linear-oblong or linear, 0.5-4.3 cm. long, 0.5-9.0 mm. broad. Sepals 2.5-4.0 mm. long; petals 7.5-9.0 mm. long. North Auckland: Kaitaia to the Kawakawa River.....14a. *P. p. pimeleoides*
Shrubs prostrate; leaves elliptic or elliptic-obovate, 9-13 mm. long, 4.5-7.0 mm. broad in sun, 1.0-2.7 cm. long and 6-13 mm. broad in shade. Sepals 4.5-5.0 mm. long; petals 11.0-11.5 mm. long. North Auckland: Kerr Point, North Cape.....14b. *P. p. major*

14a. *PITTOSPORUM PIMELEOIDES* ssp. *pimeleoides*

- Pittosporum pimeleoides* A. Cunn. ex Putterl. Syn. Pittosp. p. 15. 1839, ex char. (T.: R. Cunningham s.n.).
Pittosporum crenulatum R. Cunn. ex Putterl. Syn. Pittosp. p. 15. 1839. (T.: Huegel 261).
Pittosporum reflexum R. Cunn. ex A. Cunn. in Ann. Nat. Hist. 4: 108. 1839. (T.: R. Cunningham 40, 617 !).
Pittosporum radicans R. Cunn. ex A. Cunn. loc. cit. 1839. (T.: R. Cunningham 200, 619 !).
Pittosporum pimeleoides R. Cunn. ex A. Cunn. var. *reflexum* (A. Cunn.) Hook. f. Fl. Nov. Zel. 1: 24. 1853.
Pittosporum gilliesianum Kirk, in N.Z. Inst. Trans. & Proc. 1: 143. 1868. (T.: Kirk s.n., 95 !).
Pittosporum pimeleoides R. Cunn. ex A. Cunn. ssp. *reflexum* (A. Cunn.) Kirk, in N.Z. Inst. Trans. & Proc. 4: 263. 1872.
Pittosporum pimeleoides R. Cunn. ex A. Cunn. var. *gilliesianum* (Kirk) Kirk, loc. cit. 264. 1872.

Occasional from Kaitaia to Kawakawa in North Auckland, New Zealand.
Flowers from March to May.

NEW ZEALAND: NORTH AUCKLAND: Kaitaia, H. B. Matthews s.n. (AK); in Kauri (*Agathis australis*) forest, Fairburn, Mangonui, R. H. Matthews & Carse s.n. (AK, MO); south bank of Oruru River, half-mile southwest of Taipa, 100' above sea-level, in remnant of *Agathis australis* forest, Cooper 36009 (AK, MASS, MO); same locality,

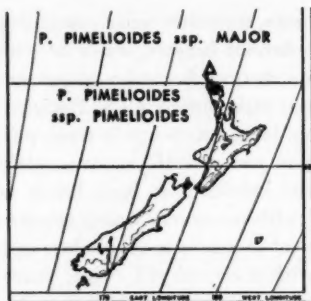


Fig. 19. *P. pimeleoides* ssp. *major* and ssp. *pimeleoides*. Names on map should read *pimeleoides*.

Powell 26437 (AK); hills north of Mangonui Harbour, Cheeseman s.n. (AK, BM); same locality, Kirk s.n. (US), 515 (BM); Waitetoki stream, near Mangonui, Cheeseman s.n. (AK); Mangonui, Kirk 95 (K, as *P. gilliesianum*); at Wangaroa and the Bay of Islands, in thickets on the slopes of hills, R. Cunningham 40, 617 (K, as *P. reflexum*); in dry woods at Wangaroa and the Bay of Islands, R. Cunningham 40, 618 (K, as *P. pimeleoides*); Bay of Islands, Wilkes s.n. (K); same locality, Hector s.n. (K); same locality, Kirk s.n. (A); in dry woods on hills, Wykari, [Hooker] 191 (K); Kawa Kawa River, Kirk s.n. (GH, MO); same locality, Kirk 538 (K); about the roots of Kauri, principally in a forest near the head of the Kawa Kawa, R. Cunningham 200, 619 (K, as *P. radicans*). WITHOUT LOCALITY: Buchanan s.n. (AK); Colenso s.n. (K); A. Cunningham 618 (K); Edgerley s.n. (K); "Auckland", Kirk s.n. (K); a small shrub in woods, Hooker 352 (K); Wilkes s.n. (US); ora septentr. Huegel 25/2, 26 (R. Cunningham) (W).

Flowers which appear to be female have capitate obscurely 2-lobed stigmas, styles only about 1.5 mm. long, and plumper ovaries 2 mm. long by 1 mm. broad. The pistil is exerted 1 mm. or more beyond the stamens, which have sagittiform probably sterile anthers only 0.5 mm. long. Flowers which appear to be male have weakly capitate stigmas, styles 3.0 - 3.5 mm. long, and thinner ovaries 1.0 - 1.5 mm. long and 0.5 - 1.0 mm. broad. The pistil is level with the anthers, which are ovoid, apparently functional, and 1.0 - 1.5 mm. long. The pedicels of "female" flowers are markedly shorter than those of "male flowers".

The ranges of *P. pimeleoides* and *P. reflexum* are not distinct, and I cannot find any constant morphological characters to separate *P. reflexum* as a species or variety. I suspect that most of the variation in leaf size and shape is caused by ecological factors, but have seen too few living plants to be certain. In the discussion of *P. eugenioides*, later in this work, the priority of the specific names of A. Cunningham (Ann. Nat. Hist. 4: 108. 1839) over those of Putterlick (Syn. Pittosp. p. 15. 1839) is discussed.

14b. *PITTOSPORUM PIMELEOIDES* ssp. *major* (Cheeseman) R. C. Cooper, *stat. nov.*

Pittosporum pimeleoides R. Cunn. ex A. Cunn. var. *major* Cheeseman, Man. N.Z. Fl. p. 60. 1906. (T.: Cheeseman s.n. !).

Found only on Kerr Point, North Cape, New Zealand. Flowers in June.

NEW ZEALAND: NORTH AUCKLAND: Kerr Point, North Cape, *Cheeseman s.n.* (AK); same locality, *Michie 80/45* (AK).

Kerr Point was formerly an island but now is joined to the North Island of New Zealand by a sand bar some 70 miles long, built probably during the Castlecliffian (upper Pliocene) period. Several species of plants are endemic to Kerr Point, but I hesitate to recognize *ssp. major* as a distinct species as it is very similar to *ssp. pimeleoides* in the characters of the flowers and fruits.

15. *PITTOSPORUM PATULUM* Hook. f. Handb. N.Z. Fl. p. 19. 1864 (T.: *Sinclair s.n.* 1).

Shrubs 1 - 5.0 m. tall; branchlets grayish-brown, the young parts brown-tomentose, soon glabrous. Leaves alternate, 2 - 6 cm. long, 3 - 10 mm. broad; juvenile leaves usually longer and narrower than the adult, linear, deeply lobed to pinnatifid, the lobes variously toothed; adult leaves linear-oblongate, entire to crenate-serrate, obtuse to acute at apex, attenuate at base, dark green above, paler beneath, glabrous, coriaceous, margins flat, rarely revolute, costa raised above and below, side veins 10 - 15 per side, anastomosing, usually obscure when juvenile but distinct above when adult; petioles 2 - 7 mm. long, brown-tomentose when young, glabrate. Flowers terminal, 3 - 7, fascicled; pedicels 7 - 15 mm. long, contracted in fruit, brown-tomentose, subtended by a whorl of leaves and numerous caducous, sparsely tomentose bud scales 1 - 2 mm. long. Sepals rarely imbricate at base, ovate-lanceolate, irregularly toothed above, acuminate, 4 - 6 mm. long, 1.5 - 2.5 mm. broad, glabrous; petals oblong, obtuse, 9 - 11 mm. long, 2 - 3 mm. broad, free or coherent at the base, spreading from above the middle, purple; stamens 4 - 7 mm. long, anthers about 1 mm. long and broad. Pistil at anthesis slightly exserted; ovary 2.5 - 3.0 mm. long, 1 - 2 mm. broad, glabrous; style 1.5 - 3.5 mm. long; stigma capitate and 2-lobed or truncate. Capsules cordate, globose to subglobose, 2-valved, 6 - 11 mm. in diameter, glabrous; valves convex to weakly sulcate in transverse section, less than 1 mm. thick, coriaceous, with a conspicuous placenta bearing 2 rows of short stout funicles from the base to just above the middle; seeds about 18 per capsule, black, irregular.

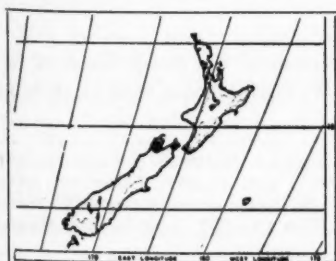


Fig. 20. *P. patulum*.

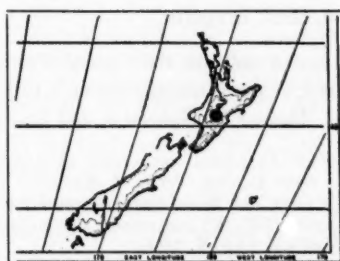


Fig. 21. *P. turneri*.

Rare and local in the northern ranges of the South Island of New Zealand.

NEW ZEALAND: NORTH AUCKLAND: Kerr Point, North Cape, *Cheeseman s.n.* (AK); near Collingwood, *Gibbs s.n.* (BM); Lake Rotoiti, *Buchanan s.n.* (AK); same locality, *Cheeseman s.n.* (AK); Spencer Mountains, *Kirk s.n.* (GH, MO); Spencer Mountains, Glacier Gully, *Laing s.n.* (NSW); woods, Upper Waiau, *Travers s.n.* (K); 5000', same locality, *Sinclair s.n.* (K).

16. *PITTOSPORUM TURNERI* Petrie, in N.Z. Inst. Trans. & Proc. 55: 95. 1924. (T.: *Matthews & Carse s.n.*!).

Shrubs or small trees 2 - 9 m. tall; branchlets dark gray or brown, sharply divaricating and matted at juvenile stage or on lower part of stem, fastigate in adult stage or on upper part of stem, white-tomentulose when young, soon glabrate. Leaves alternate, clustered at the tips of short branchlets, brownish-green above, paler beneath, tomentulose when young, soon glabrate, coriaceous, with slightly thickened and revolute margins, costa obscure above, raised beneath, secondary veins 10 - 13 per side, anastomosing, obscure above, distinct beneath. Juvenile leaves orbicular, obovate, or linear, entire or variously lobed and parted, 2 - 15 mm. long, 1 - 5 mm. broad, adult leaves obovate to oblanceolate, obtuse to acute at apex, attenuate at base, entire or obscurely crenate, 1 - 4 cm. long, 6 - 12 mm. broad; petioles 0.5 - 2.5 mm. long, 0.5 - 1.5 mm. broad, tomentulose when young, soon glabrate. Flowers terminal, 4 - 12, fascicled; pedicels 1 - 3 mm. long, accrescent in fruit, brown-tomentose, subtended by an approximate whorl of leaves and numerous caducous tomentose-ciliate bud scales 2 - 7 mm. long. Sepals slightly imbricate at base, lanceolate, acute to acuminate, 3.5 - 5.0 mm. long, 1 - 2 mm. broad, ciliolate, tomentulose; petals oblong, subacute to obtuse, 6 - 9 mm. long, 2.0 - 2.5 mm. broad, free spreading from above the middle, pink or purple; stamens 4.0 - 5.5 mm. long, anthers ovate-elliptic, 1.5 - 2.0 mm. long, 0.5 - 1.0 mm. broad. Pistil at anthesis slightly shorter than or equal to the stamens; ovary 2.5 - 3.5 mm. long, 1.0 - 1.5 mm. broad, tomentulose; style about 2 mm. long; stigma weakly capitate to truncate. Capsules globose, 2-, rarely 3-, valved, apiculate, 5 - 8 mm. in diameter, slightly rugose; valves convex or sometimes sulcate in transverse section, less than 1 mm. thick, coriaceous, with a conspicuous placenta bearing several pairs of short stout funicles between the base and the middle; seeds 3 - 10, black, irregular.

Found only on the Central Volcanic Plateau of the North Island of New Zealand, at forest margins between Erua and Waimarino, about 1000 m. above sea-level. Flowers in November and December.

NEW ZEALAND: VOLCANIC PLATEAU: Waimarino, *Matthews & Carse s.n.* (AK, MO); same locality, *Petrie & Matthews s.n.* (AK); same locality, *Turner s.n.* (AK); 3000', Erua and Waimarino, *Attwood s.n.* (AK, K, MO); forest margins, Waimarino, *Allan s.n.* (GH, K); on stream side near Erua, *Allan s.n.* (K); same locality, *Moore & Cranwell s.n.* (AK, K, MO).

17. *PITTOSPORUM OBCORDATUM* Raoul, in Ann. Sci. Nat. III, 2: 121. 1844. (T.: *Raoul s.n.*!).

Shrubs to small trees 2 - 5 m. tall; branchlets divaricating, gray to reddish-brown, tomentulose when young, soon glabrate. Leaves alternate at seedling stage and on young branchlets, later restricted to the tips of arrested branchlets 1 - 2 mm. long, tomentulose to glabrous, submembranous when young, coriaceous when adult, margins entire or crenate, flat or revolute, sparsely ciliolate, costa immersed above, raised beneath, secondary veins 2 - 4 per side, anastomosing, obscure above, distinct or obscure beneath; juvenile leaves at first oblong to elliptic, entire, 5 - 9 mm. long, 2.5 - 4.0 mm. broad, soon linear to spatulate, variously lobed, toothed and parted, rarely entire, 1.3 - 3.6 cm. long, 2 - 12 mm. broad; adult leaves orbicular to obovate, obcordate to obtuse at apex, attenuate at base, 4 - 14 mm. long and broad; petioles 0.5 - 5.0 mm. long, tomentulose to glabrous, usually narrowly winged. Inflorescences axillary or terminal, on minute arrested branchlets, 1- to 5-flowered, umbelliform; pedicels up to 2 mm. long, accrescent in fruit, tomentulose, subtended by 1 - 5 leaves and numerous caducous sparsely ciliolate and tomentulose bracts 1 - 2 mm. long. Sepals slightly imbricate at base, lanceolate-subulate acute, 1.5 - 3.0 mm. long, 0.5 - 1.0 mm. broad, ciliolate, tomentulose; petals linear-oblong, obtuse, 4.0 - 6.5 mm. long, 0.7 - 1.5 mm. broad, connate in a cylindrical tube with spreading or reflexed tips, pale purple, yellow, or white, sometimes with a reddish-purple stripe; stamens 2.5 - 4.5 mm. long, anthers sagittiform to ovate, 0.5 - 1.0 mm. long. Pistil at anthesis slightly shorter or longer than the stamens; ovary 1.5 - 3.3 mm. long, 0.5 - 1.5 mm. broad, tomentulose; style 1 - 2 mm. long; stigma capitate and obscurely 2-lobed or truncate. Capsules ellipsoid to subovoid, 2-valved, apiculate, with persistent sepals at base, 6.5 - 10.0 mm. long, 5 - 7 mm. broad, frequently dehiscing laterally by one opening, green to black, slightly rugose, sparsely tomentulose, glabrate; valves convex in transverse section, less than 1 mm. thick, coriaceous, with a slightly thickened placenta bearing 2 - 4 stout flattened funicles up to 1 mm. long from the base to just above the middle; seeds 4 - 7, reddish-black to black, irregular.

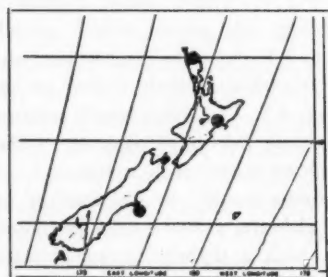
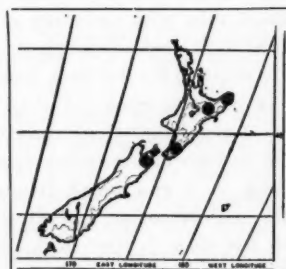
Found in three isolated localities in New Zealand. Flowers in October and November.

NEW ZEALAND: NORTH AUCKLAND: near Lake Tongong, Kaitaia, *H. B. Matthews s.n.* (AK, CANTY); same locality, *R. H. Matthews s.n.* (AK, BM); in open on river bank, west of wireless station, Kaitaia, *H. B. Matthews & Carse s.n.* (AK, CANTY); in alluvial land subject to flooding, in shade of river bank below Kaitaia, *R. H. Matthews & Carse s.n.* (AK, MO); Kaitaia, *H. B. Matthews s.n.* (AK, MO); 1855 (K). EAST CAPE: Wairoa River, *Sainsbury s.n.* (AK, CANTY); Hurumua, near Wairoa, *Hodgson s.n.* (CANTY). CANTERBURY: presqu'île de Banks, *Raoul s.n.* (P), 80 (K).

The type material was collected by Raoul between 1840 and 1842 at Banks Peninsula in the South Island of New Zealand, but the plant has not been found again in that locality. In 1901 R. H. Matthews found two or three plants at Kaitaia in the extreme north of the North Island, and about 1923 G. O. K. Sainsbury discovered twelve or fifteen plants near Wairoa on the east coast of the North

Island. The plants of these widely separated stands are not floristically identical and Laing & Gourla¹⁸¹ described the Kaitaia population as *P. obcordatum* var. *kaitaiaensis* but their description lacks a Latin diagnosis and is therefore invalid¹⁸². The two authors mentioned separated the Kaitaia plants as a variety on their seedling form, but I do not consider that their evidence is adequate. Cheeseman¹⁸³ noted that specimens from Kaitaia had slightly larger young leaves, and Sainsbury pointed out that the bark of the Wairoa plants is reddish-gray rather than gray, but the differences in the material which I have seen are so slight that I do not consider that varietal names are warranted.

The flowers of Kaitaia and Wairoa plants appear to be unisexual. Flowers which may be female have capitate, 2-lobed stigmas, short styles, plump ovaries 3 mm. long, 1.0 - 1.5 mm. broad, stamens 0.5 - 1.3 mm. shorter than the pistil and sagittiform probably abortive anthers under 1 mm. long. Flowers which may be male have weakly capitate to truncate stigmas, longer styles, more slender ovaries 1.5 - 2.5 mm. long, 0.5 - 1.0 mm. broad, stamens almost equal to or slightly longer than the pistil, and ovate probably functional anthers about 1 mm. long. The single Akaroa specimen has flowers which appear to be male. Godley¹⁸⁴ has informed me that the species is dioecious.

Fig. 22. *P. obcordatum*.Fig. 23. *P. rigidum*.

18. *PITTOSPORUM RIGIDUM* Hook. f. Fl. Nov. Zel. 1: 22. *t. 10.* 1853. (T.: *Colenso s.n. !*).

Shrubs to 3 m. tall; branchlets erect, not interlaced or divaricating, grayish-brown, rusty- to gray-tomentose, glabrate. Leaves alternate, dark green above, paler beneath, costa raised or immersed above, raised beneath, secondary veins usually obscure; juvenile leaves obovate, oblanceolate, or elliptic-oblong, acute,

¹⁸¹ Laing & Gourlay, in Trans. Roy. Soc. N.Z. 65: 47. 1935.

¹⁸² Int. Code Bot. Nomencl. 1952. Art. 44.

¹⁸³ Man. N.Z. Fl. ed.2. p.490. 1925.

¹⁸⁴ Personal communication.

rarely obtuse at apex, attenuate at base, variously incised, toothed or crenate, occasionally entire, 5 - 13 mm. long, 3 - 10 mm. broad, tomentulose, soon glabrate, membranous to coriaceous; adult leaves elliptic-oblong, occasionally oblanceolate to obovate, rarely lanceolate, obtuse to subacute at apex, obtuse at base, entire, rarely toothed, 5 - 24 mm. long, 3 - 13 mm. broad, rusty-tomentose, glabrate, coriaceous, slightly revolute; petioles 1 - 3 mm. long, rusty-tomentose. Flowers terminal or axillary, solitary; pedicels 0.5 - 4.0 mm. long, accrescent in fruit, subtended by one to several leaves and a whorl of caducous brown-tomentulose bud scales 1 - 2 mm. long. Sepals not imbricate, lanceolate-oblong, acute, 3.5 - 6.0 mm. long, 1.0 - 1.5 mm. broad, sparsely ciliolate with scattered hairs; petals linear-oblong, obtuse, 8 - 12 mm. long, 2 mm. broad, free, patent with reflexed tips, dingy purple; stamens 4.0 - 6.5 mm. long, anthers sagittiform or ovate, 0.6 - 1.8 mm. long, 0.3 - 1.0 mm. broad. Pistil at anthesis slightly shorter than the stamens; ovary 2.0 - 2.5 mm. long, 1 - 2 mm. broad, tomentose; style 2.5 mm. long; stigma capitate to truncate. Capsules subglobose, 2-valved, apiculate, 8 - 10 mm. long, 6 - 10 mm. broad, tomentose, glabrate, rugose; valves convex in transverse section, less than 1 mm. thick, coriaceous, with a slightly thickened placenta bearing 1 - 5 thick strap-like funicles up to 1.5 mm. long near the middle; seeds 3 - 9, black, irregular.

Occurs from the East Cape of the North Island of New Zealand to Marlborough in the South Island, along the mountain ranges between 650 and 1400 m. Flowers in November and December.

NEW ZEALAND: EAST CAPE: Mt. Hikurangi, *Adams s.n.* (AK); 4000', same locality, *Petrie s.n.* (AK); 4300', undershrub in *Nothofagus* (beech) forest, Maungapohatu, Urewera, *Moore & Cranwell s.n.* (AK). WELLINGTON: Mt. Holdsworth, 3500', *Townson s.n.* (BM); same locality, at forest line, *Cockayne 9076* (A); same locality, *Aston s.n.* (AK, NSW); same locality, *Jones s.n.* (MO); 3000'-4000', Mt. Hector, *Petrie s.n.* (AK); same locality, *Attwood s.n.* (AK); Mt. Waiopahu, *Attwood s.n.* (AK); Mt. Omega, *Turner 156* (AK); Field Hut, *Moore & Cranwell s.n.* (AK). MARLBOROUGH: Mt. Stokes, *Turner s.n.* (AK). WITHOUT LOCALITY: *Colenso s.n.*, 45, 64, 924 (K); *W. T. L. Travers s.n.* (K).

The flowers are of two kinds: those which appear to be male have truncate stigmas, styles about 2.5 mm. long, slender ovaries 2.5 mm. long, 1 mm. broad, stamens 5.5 - 6.5 mm. long, and probably functional ovoid anthers 1.5 - 2.0 mm. long, 1 mm. broad. The flowers which appear to be female have capitate stigmas, styles about 2 mm. long, plump ovaries 2.0 - 2.5 mm. long, 2 mm. broad, stamens about 4 mm. long, and probably abortive sagittiform anthers 0.6 - 0.8 mm. long, 0.3 - 0.5 mm. broad.

The flowering material available is inadequate but in the specimens seen the male flowers had pedicels up to 4 mm. long while the female flowers had pedicels only 0.5 mm. long. Godley¹⁶⁵ has informed me that the species is dioecious.

Cockayne¹⁶⁶ divided *P. rigidum* Hook. f. into two species, and kept the name

¹⁶⁵ Personal communication.

¹⁶⁶ N.Z. Inst. Trans. & Proc. 47:111. 1915.

P. rigidum for the East Cape and Tararua population, as Colenso gathered the type material in the East Cape district.

19. *PITTIOSPORUM CRASSICAULE* Cockayne ex Laing & Gourlay, in Trans. Roy. Soc. N.Z. 65: 50. 1935. (T.: Laing & Gourlay s.n.!).

Pittosporum lineare Laing & Gourlay, loc. cit. 57. 1935. in part. (quoad MacMabon 351).

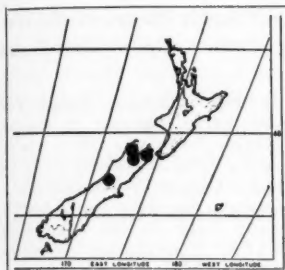
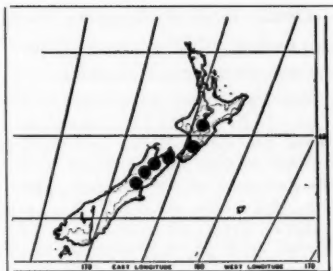
Shrubs to 4 m. tall; main branches usually erect, often closely compressed; branchlets divaricating, opposite or whorled at the nodes, stout, often spinose at the tips, white-tomentose. Leaves alternate at seedling and juvenile stage, restricted to the apex of short, stout, sometimes minute branchlets at adult stage, submembranous when juvenile, coriaceous when adult, green above, paler beneath, sparsely ciliolate and tomentulose when young, glabrate, costa slightly raised above and beneath or immersed, secondary veins obscure; juvenile leaves obovate to oblanceolate, variously lobed and parted, lobes irregularly dentate, 4.5 - 12.0 mm. long, 3 - 8 mm. broad; adult leaves linear or elliptic-oblong to oblanceolate, obtuse to subacute at apex, attenuate at base, entire, occasionally lobed or toothed, especially in shade forms, 3.5 - 17.0 mm. long, 1 - 4 mm. broad; petioles 1.0 - 1.5 mm. long, glabrous. Flowers terminal, 1 - 3, solitary or fascicled, sessile on minute arrested branchlets, subtended by 1 - 6 leaves and numerous persistent tomentulose bud scales about 1 mm. long. Sepals imbricate at base, lanceolate-ovate, 1.2 - 1.5 mm. long, 1 mm. broad, glabrous, ciliolate; petals linear-oblong, obtuse, 4.0 - 7.5 mm. long, 1.2 - 1.5 mm. broad, coherent in a cylindrical tube, tips spreading, later recurved, purple; stamens 1.5 - 4.5 mm. long, anthers ovate, 0.6 - 1.0 mm. long, 0.4 - 0.6 mm. broad. Pistil at anthesis slightly shorter or longer than the stamens; ovary 1.5 - 2.5 mm. long, 1 - 2 mm. broad, tomentulose; style 1 - 2 mm. long; stigma capitate or truncate. Capsules subglobose to globose, 2-valved, apiculate, 4.5 - 7.0 mm. long, 5.5 - 7.0 mm. broad, tomentulose or glabrate, rugose; valves convex in transverse section, less than 1 mm. thick, almost woody, with a placenta thickened from the middle to the base, bearing 1 - 2 slender peg-like funicles near the middle; seeds 1 - 3, black, round to irregular.

Occurs in Marlborough, Nelson, Westland, and Canterbury, mainly on the western side of the South Island of New Zealand. Flowers in October and November.

NEW ZEALAND: MARLBOROUGH: Pelorus Valley, MacMabon 35 (AK). NELSON: 500', Maitai Valley, Cheeseman s.n. (AK); Rocky River, Bainham, Collingwood, Wall s.n. (CANTY); Buller Valley, Townson 445 (AK); same locality, Cheeseman s.n. (AK, MO). WESTLAND: 380 m. in scrub on banks of Teremakau River, near Railway Settlement, Otira, Laing & Gourlay s.n. (CANTY). CANTERBURY: 730 m. north side of Rough Creek, near railway cottages, Arthur's Pass, Laing & Gourlay s.n. (CANTY); same locality, Laing s.n. (K); same locality, near Jack's Hut, Laing s.n. (K); roadside, same locality, Cooper 24318 (AK, US).

Flowers which may be female have capitate stigmas, and stamens 1.5 - 1.6 mm. long, with anthers 0.6 mm. long and 0.4 mm. broad. Flowers which may be male have truncate stigmas, and stamens 3.9 - 4.6 mm. long with anthers 1 mm.

long and about 0.5 mm. broad. I cannot find any consistent differences in the size of the ovaries.

Fig. 24. *P. crassicaule*.Fig. 25. *P. divaricatum*.

20. *PITTOSPORUM DIVARICATUM* Cockayne, in N.Z. Inst. Trans. & Proc. 47: 111. 1915. (T.: Cockayne 8551 !).

Pittosporum rigidum Hook. f. Fl. Nov. Zel. 1: 22. 1853, in part.

Pittosporum divaricatum Cockayne, in N.Z. Inst. Trans. & Proc. 44: 20. t. 3. f. 2 & t. 8. 1912, *nom nud*; in Austral. Assoc. Adv. Sci. Proc. 13: 219. 1912, *nom nud*.

Pittosporum lineare Laing & Gourlay, in Trans. Roy. Soc. N.Z. 65: 57. 1935, in part. (quoad Laing & Gourlay s.n.!).

Shrubs to 6 m. tall; branches thick and woody, interlaced; branchlets divaricating, opposite or whorled at the nodes, stout, often spinose at the tips, tomentulose when young, soon glabrate. Leaves alternate at seedling stage and on young branchlets, later restricted to the tips of arrested branchlets 1 - 5 mm. long, submembranous when juvenile, coriaceous when adult, green above, paler beneath, glabrous, costa immersed above, sunken beneath, secondary veins obscure; juvenile leaves oblong, obovate to lanceolate, or almost linear, margins with 1 to several lobes or teeth on either side, occasionally crenate, 6 - 9 mm. long, 1 - 4 mm. broad; adult leaves linear-oblong to linear-oblong, or ovate, acute to obtuse at apex, acute at base, 4 - 10 mm. long, 2 - 7 mm. broad, smaller and entire in sun, larger and variously dentate, crenate, or lobed in shade; petioles about 1 mm. long, glabrous. Flowers terminal on short arrested branchlets, solitary, sessile or with minute pedicels, subtended by several leaves and caducous ciliate bud scales about 1 mm. long. Sepals not imbricate at base, lanceolate, acute, 1.5 - 2.5 mm. long, 0.5 - 1.0 mm. broad, glabrous, ciliate; petals linear-oblong, obtuse, 4 - 6 mm. long, 1.0 - 1.5 mm. broad, coherent in a cylindrical tube, tips spreading, purple; stamens 1.5 - 2.6 mm. long, anthers ovate or sagittiform, 0.5 - 1.4 mm. long, 0.3 - 0.7 mm. broad. Pistil at anthesis slightly exserted; ovary 1.0 - 2.2 mm. long, 0.5 - 1.0 mm. broad, glabrous; style 1.0 - 1.5 mm. long; stigma capitate to truncate. Capsules cordate or subglobose, 2-valved, acute and apiculate, 6 mm. long, 5.5 - 6.0 mm. broad, glabrous, weakly rugose; valves convex in transverse

section, less than 1 mm. thick, coriaceous, with a slightly thickened placenta bearing 1 - 2 pairs of peg-like funicles near the middle; seeds 1 - 6, black, round to irregular.

Occurs from the Ruahine Range and Central Volcanic Plateau of the North Island to Arthur's Pass on the Main Divide of the Southern Alps of New Zealand. Flowers in October and November.

NEW ZEALAND: EAST CAPE: Pukatitiri, eastern foothills of Ruahine Range, *Hodgson s.n.* (AK, CANTY). VOLCANIC PLATEAU: Lake Karioi, vicinity of Ruapehu, *Attwood s.n.* (AK, MO). WELLINGTON: Tararua Range, *Petrie s.n.* (AK). MARLBOROUGH: Picton, *MacMahon s.n.* (AK, NSW); Koromiko, *Laing & Gourlay* [The label of the Kew sheet of the Koromiko plant is noted by H. H. Allan as "col. H. Jenkins end of Oct. 1932."] *s.n.* (CANTY, K). NELSON: Dun Mountain, *Sainsbury s.n.* (CANTY); Wangapeka River, *Cheeseman s.n.* (AK); 2000', in bog forest on the Rahu Saddle, *Cockayne 8551* (A, K); without locality, *Bidwill 96* (K). CANTERBURY: Lewis Pass, *Morrison 39* (A, CANTY); Cass River, *Kirk s.n.* (GH, NSW); south side of Rough Creek, Arthur's Pass, *Laing & Gourlay s.n.* (CANTY).

It is with hesitation that I treat *P. lineare* as a synonym of *P. divaricatum* and *P. crassicaule*. Laing and Gourlay, the two authors of *P. lineare*, cultivated and studied the small-leaved New Zealand species of *Pittosporum* for many years before publishing their results, but in the material cited by them there appear to be two distinct entities: the Koromiko plants (*Laing & Gourlay s.n.*) which have flowers with sepals 2.0 - 2.5 mm. long, capitate stigmas, styles 1.0 - 1.2 mm. long, glabrous ovaries 2.0 - 2.2 mm. long, and stamens about 2 mm. long; and the Pelorus Valley plants (*MacMahon s.n.*) which have flowers with sepals 1.0 - 1.5 mm. long, truncate stigmas, styles about 1.8 mm. long, tomentulose ovaries 1.5 mm. long, and stamens nearly 4 mm. long. The linear entire leaves of the Koromiko plant give it a very different appearance from most specimens of *P. divaricatum*, but the flowers are within the range of variation of *P. divaricatum*, and similar plants with linear entire leaves and bearing the distinctive cordate glabrate fruits of *P. divaricatum* occur on the Volcanic Plateau (*Attwood s.n.*), and in cultivation (*Cooper 36299*). The tomentulose ovary of the Pelorus Valley plants is a feature of *P. crassicaule*, *P. rigidum*, and *P. obcordatum*, but the other characters of the flower, fruit, and foliage are similar to those of *P. crassicaule*. Consequently with some misgivings I have included the collection in that species.

In the material examined there are slight differences in the size and form of the flowers. Flowers which may be female have capitate stigmas, ovaries 1.5 - 2.2 mm. long, 1 mm. broad, stamens 1.5 - 2.5 mm. long and sagittiform to ovate anthers 0.5 - 0.9 mm. long, 0.3 - 0.5 mm. broad. Flowers which may be male have truncate stigmas, ovaries 1.0 - 1.5 mm. long, 0.5 - 0.6 mm. broad, stamens about 4.0 mm. long, and ovate anthers 1.0 - 1.5 mm. long, 0.6 - 0.7 mm. broad.

21. *PITTOSPORUM ANOMALUM* Laing & Gourlay, in Trans. Roy. Soc. N.Z. 65: 54. 1935. (T.: *Laing & Gourlay s.n.*!).

Shrubs, prostrate in the sun and with rigid, almost spinose branches, semi-prostrate in shade and forming subglobose masses up to 1 m. tall and 2 m. in

diameter with non-spinose, interlaced branches; branchlets brownish-gray, tomentulose when young, soon glabrate. Leaves alternate on juvenile plants and young branchlets, later restricted to the tips of arrested branchlets, oblong-linear to oblanceolate-linear, obtuse to subacute at apex and base, submembranous when young, coriaceous when adult, green in summer, brownish-red in winter, paler beneath, sparsely tomentulose when young, soon glabrate, costa immersed above, raised beneath, secondary veins obscure; juvenile leaves dentate-serrate, 8 - 12 mm. long, 2 - 3 mm. broad; adult shade leaves deeply doubly dentate or serrate to crenate, occasionally entire, 5 - 10 mm. long, 1.0 - 2.5 mm. broad; adult sun leaves entire, occasionally crenate, 2 - 5 mm. long, 1.0 - 1.5 mm. broad; petioles up to 1 mm. long, glabrous. Flowers terminal on short arrested branchlets, solitary, sessile, subtended by several leaves and caducous ciliolate bud scales 2 mm. long. Sepals not imbricate at base, lanceolate, 2 mm. long, 0.5 - 1 mm. broad, glabrous, ciliolate; petals obovate to oblanceolate, obtuse to subacute, 2.5 - 4.0 mm. long, 1.2 - 2.0 mm. broad, spreading, creamy yellow, purple at the edges and tips; stamens 2 - 3 mm. long, anthers ovate to orbiculate, 0.5 - 0.8 mm. long, 0.3 - 0.8 mm. broad. Pistil at anthesis equal to the stamens; ovary 1.0 - 1.3 mm. long, 0.8 - 0.9 mm. broad, glabrous; style 0.5 - 12.2 mm. long; stigma capitate and 2-lobed or truncate. Capsules ovoid, 2-valved, acute to acuminate, apiculate, 5.5 - 7.0 mm. long, 3 - 4 mm. broad, glabrous; valves convex in transverse section, less than 1 mm. thick, subcoriaceous, splitting longitudinally on dehiscence and leaving a papery endocarp covering the seeds; placenta unthickened, bearing 1 - 2 short stout funicles about the middle; seeds 2 - 4, black, round to irregular.

Occurs on the Central Volcanic Plateau of the North Island, and at Nelson and Arthur's Pass in the South Island of New Zealand. Flowers in December and January.

NEW ZEALAND: VOLCANIC PLATEAU: shrub steppe, Mt. Hauhangatahi, *Carse & Matthews s.n.* (CANTY); Hauhangatahi, *Moore & Cranwell s.n.* (AK, MO); 3000', in tussock near Chateau Tongariro, Mt. Ruapehu, *Godley 24963* (AK). NELSON: wooded peak, *Gibbs s.n.* (CANTY). CANTERBURY: 3000', Arthur's Pass, *Laing & Gourlay s.n.* (CANTY); same locality, "Jack's Hut", *Laing s.n.* (K).

Flowers which may be female have capitate 2-lobed stigmas, styles 0.5 - 0.7

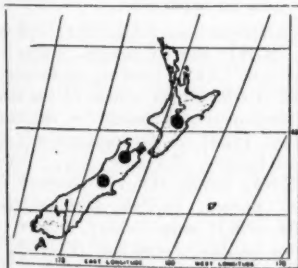


Fig. 26. *P. anomalum*.

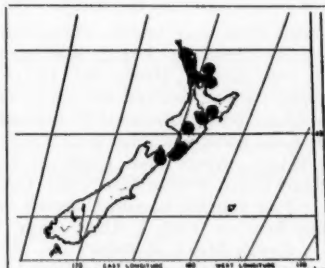


Fig. 27. *P. cornifolium*.

mm. long, and ovate anthers 0.5 mm. long, 0.3 mm. broad, on filaments about 1.5 mm. long. Flowers which may be male have truncate stigmas, styles 1.0 - 1.2 mm. long, and orbiculate anthers 0.7 - 0.8 mm. long, 0.5 - 0.8 mm. broad, on filaments 1.5 - 2.2 mm. long. There is little difference in ovary size in the specimens which I have seen

22. *PITTOSPORUM CORNIFOLIUM* A. Cunn. ex Hook. in Bot. Mag. t. 3161. 1832. (T.: A. Cunningham 616!).

Pittosporoides verticillata Banks & Soland. ex A. Cunn. in Ann. Nat. Hist. 4: 107. 1839, nom. nud. in synon.

Shrubs 0.5 - 2.5 m. tall, epiphytic, rarely terrestrial; branchlets forked or verticillate, dark brown, glabrous. Leaves verticillate, obovate- to ovate-elliptic, acute to subacuminate at apex, acute to obtuse at base, entire, 2 - 10 cm. long, 1 - 5 cm. broad, light green above, paler beneath, ciliate when young, soon glabrate, coriaceous with thickened slightly revolute margins, costa raised above, immersed beneath, secondary nerves obscure above, distinct beneath; petioles 0.5 - 3.0 mm. long and 0.5 - 2.0 mm. broad, glabrous. Inflorescences terminal, 1- to 10-flowered, usually umbelliform; pedicels 2 - 15 mm. long, accrescent in fruit, brown-tomentose, subtended by a whorl of leaves and numerous caducous bud scales about 1 mm. long. Sepals not imbricate, narrow-lanceolate, acute, 4 - 7 mm. long, about 1 mm. broad, spreading, sparsely puberulent; petals linear-lanceolate, acute to acuminate, 8 - 12 mm. long, 1.5 - 2.0 mm. broad, coherent in a tube with reflexed tips, yellow; stamens 4 - 6 mm. long, anthers sagittiform to elliptic-oblong, 1 - 2 mm. long, 0.5 - 1.0 mm. broad. Pistil at anthesis slightly longer to slightly shorter than the stamens; ovary 1.5 - 3.0 mm. long, 0.5 - 2.0 mm. broad, villous; style 2.5 - 4.0 mm. long; stigma capitate and 2-lobed to truncate. Capsules ellipsoid, 2- or 3-valved, about 1.7 cm. long, 1.2 cm. broad, glabrate; valves convex in transverse section, less than 1 mm. thick, coriaceous, with a short basal placenta bearing several strap-like funicles up to 5 mm. long; seeds 4 - 8, black, irregular.

Occurs from sea-level to 650 m. throughout the North Island and northern part of the South Island of New Zealand; common in the northern part of the North Island, rarer to the south. Flowers from June to September.

NEW ZEALAND: NORTH AUCKLAND: Kaitaia, *Matthews s.n.* (AK, MO); Okahu, Kaitaia, *Matthews s.n.* (AK); Whangaroa, *Kirk s.n.* (GH); Bay of Islands, *Wilkes s.n.* (US); same locality, *Hooker s.n.* (K); Opua, *Mackie s.n.* (AK); growing uniformly as an epiphyte upon trees and frequently in the tufts of *Astelia* which adhere to the stems of the larger timber, particularly *Kabikatea* (*Dacrydium*) in shaded woods [on the banks of the Kana Kana, and other rivers, Bay of Islands, etc., 1826], A. Cunningham 61, 616 (K); Waipoua Kauri forest, *Cockayne* 6421 (A); same locality, *Sledge* 74 (CU); Trounson Kauri forest, *Walker* 5280 (MO, US); Taranga (Hen) Island, *Moore & Cranwell s.n.* (AK); Poor Knights Islands, *Cranwell s.n.* (AK). AUCKLAND: Te Pahi, *Kirk s.n.* (A); Omaha, *Kirk s.n.* (AK, F, US); Leigh, *Buddle* 27204 (AK); same locality, *Turner s.n.* (AK); Kawau Island, *Matthews s.n.* (AK, MO); same locality, *Petrie s.n.* (CU); Birkdale, *Meebold* 5289 (BISH); Waitakere Ranges, *Cheeseman s.n.* (BISH, NSW, US); same locality, *Petrie s.n.* (NSW); epiphytic on *Metrosideros tomentosa*, Huia, *Wood s.n.*

(AK); Titirangi, *Cheeseman s.n.* (GH, NSW, US), 11 (K); Auckland, *Cranwell s.n.* (AK); Buckland, *Matthews s.n.* (AK, MO.) THAMES: Cape Colville, *Kirk s.n.* (MO); Coromandel Peninsula, *Adams s.n.* (AK); Shag Bay, Te Moehau, *Moore & Cranwell s.n.* (AK, K); Pakirarahi, *Adams s.n.* (AK); Tararu, *Kirk s.n.* (AK); Thames, *Adams s.n.* (US); in sylvis prope Tolaga [East Cape], Oporagi [Mercury Bay], *Banks & Solander s.n.* (BM). EAST CAPE: Lake Waikaremoana, *Sainsbury 15* (AK); Akatarawa Station, *Turner 162* (AK). WANGANUI: Parapara, Mangowhero, Waimarino, *Attwood s.n.* (AK); Turakina, *Allison s.n.* (A, NSW). WELLINGTON: epiphytic on *Podocarpus spicatus*, forest margin, *Fielding, Allan s.n.* (BH); Mungaroa, *Kirk 136* (BM); Orongorongo, *Kirk 130* (GH). MARLBOROUGH: terrestrial, Endeavour Inlet, Queen Charlotte Sound, *MacMahon s.n.* (AK); Tennyson Inlet, Pelorus Sound, *Turner 804* (AK). WITHOUT LOCALITY: *Banks & Solander s.n.* (AK, MO, US); *Bidwill s.n.* (K); *Colenso s.n.* (K); *A. Cunningham s.n.*, 616 (K); North Island, *A. Cunningham 616* (BM, K); ex Hort. Kew (figd. in Bot. Mag.) *s.n.* (K).

Inflorescences with up to 10 flowers appear to be male. The flowers have truncate to weakly capitate stigmas level with or shorter than the anthers, styles 3.5 - 4.0 mm. long, and ovaries 1.5 - 2.0 mm. long. I think that they are male as the ovaries are very thin, apparently abortive, and the anthers are elliptic-oblong, apparently functional. Inflorescences with only 1 or 2 flowers appear to be female. The flowers have capitate 2-lobed stigmas level with or exerted beyond the anthers, styles 2.0 - 2.5 mm. long and ovaries 3 - 4 mm. long. I think that they are female as the ovaries are plump, apparently functional, and the anthers are sagittiform and abortive. *Kirk*¹⁰⁷ and *Petrie*¹⁰⁸ described the flowers of *P. cornifolium* as unisexual, and *Cheeseman*¹⁰⁹ regarded the plants as polygamous or dioecious. Field studies are required to determine the significance of the morphological differences.

The species was described by W. J. Hooker from material grown at the Royal Botanical Gardens, Kew, and from Allan Cunningham's specimens and notes made by him in New Zealand in 1826. Two "type" sheets in the herbarium of the Royal Botanic Gardens, Kew, bear five labels, two sterile specimens, a fruiting specimen and fragments of flowers. One label is dated 1826, one 1833, two 1838, and one is undated. As the species was described in 1832 only part of the material can have been available to W. J. Hooker. Fortunately the species is distinct and the muddle of labels and specimens does not have serious consequences.

Vernacular name: Cornel-leaved Pittosporum.

23. PITTOSPORUM KIRKII Hook. f. ex Kirk, in N.Z. Inst. Trans. & Proc. 2: 92. 1869. (T.: *Kirk s.n.*!).

Shrubs 1 - 5 m. tall, epiphytic, occasionally terrestrial; branchlets reddish-purple, glabrous. Leaves subverticillate, linear-obovate to oblong-elliptic, acute or obtuse at the apex, acute at the base, entire, 4 - 11 cm. long, 0.7 - 3.2 cm. broad, pale green above, lighter beneath, glabrous, coriaceous, with thickened and slightly revolute margins, costa raised above, flattened beneath, secondary veins

¹⁰⁷ Students' Fl. N.Z. p. 49. 1899.

¹⁰⁸ N.Z. Inst. Trans. & Proc. 53:365. 1921.

¹⁰⁹ Manual N.Z. Fl. ed. 2 p. 495. 1925.

about 18 per side, anastomising, obscure; petioles 3 - 16 mm. long, 1 - 2 mm. broad, glabrous, purple. Inflorescences terminal, 3- to 10-flowered, umbelliform; pedicels 5 - 10 mm. long, contracted in fruit, glabrous, subtended by an approximate whorl of leaves and by numerous caducous glabrous bud scales 1 - 2 mm. long. Sepals imbricate at base, lanceolate, acuminate, 6 - 10 mm. long, 1.5 - 4.0 mm. broad, glabrous; petals oblanceolate, acuminate, 1.5 - 2.1 cm. long, 2.5 - 3.5 mm. broad, fused slightly above the base to the middle, sharply recurved above, yellow; stamens 6 - 7 mm. long, anthers elliptic-oblong, 2.5 - 3.0 mm. long. Pistil at anthesis equalling or slightly longer than the stamens; ovary 3 - 4 mm. long, 1.5 mm. broad, tomentulose; style about 3 mm. long, stout, stigma capitate. Capsules ellipsoid, 2-, rarely 3-, valved, apiculate, 2.6 - 3.9 cm. long, 1.1 - 1.7 cm. broad, green to yellow, glabrate; valves convex in transverse section, about 1.5 mm. thick, coriaceous, with a placenta bearing slender strap-like funicles up to 4 mm. long, from the base for three-fourths the length of the valve; seeds about 40, black, irregular.

Occasional from 250 to 1000 m. in North Auckland, Auckland, Thames, including Great Barrier Island, and Wanganui districts of New Zealand.

Flowers from November to January.

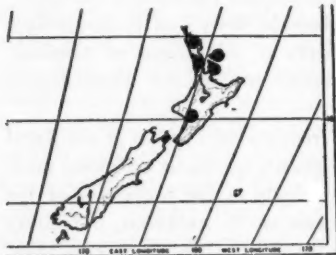


Fig. 28. *P. kirkii*.

NEW ZEALAND: NORTH AUCKLAND: 2000', Maungataniwha, Manganui, *Cheeseman s.n.* (AK, K); epiphytic on a dead log, Warawara State Forest, North Hokianga, *Cooper 35572* (AK, MO); Hokianga, *Petrie s.n.* (K); same locality, Otua, *Berggren s.n.* (BM); epiphytic on tall tree, *Waipoua kauri* forest, *Cockayne 6419* (A); same locality, *Turner 793* (AK); same locality, *Jessup 26640* (AK); Taheke, *Cheeseman s.n.* (AK); ridge near Puketutu, Takahue side, *Petrie s.n.* (AK, MO). AUCKLAND: Titirangi Ranges, *Cheeseman s.n.* (AK, GH, K, US), 12 (K); Huia, *Mackie s.n.* (AK); Huia dam, epiphytic in second-growth *Agathis australis* forest, *Wood s.n.* (AK). THAMES: epiphytic, Kaeoruruwahine forest, Great Barrier Island, *Kirk s.n.* (F, GH, MO); 2000', Great Barrier Island, *Kirk 63* (K); Cape Colville, *Kirk s.n.* (AK); same locality, 2300', *Hector s.n.* (BM); same locality, *Adams s.n.* (AK); Thames and Thames Goldfield, 2500', *Kirk s.n.* (A, AK, K), 63 (K); same locality, *Adams s.n.* (AK); mixed forest, 1500', Wairongomai Mine, Te Aroha, *L. S. Gibbs, 1298* (BM); epiphytic, c. 2000', Te Moehau, *Moore & Cranwell s.n.* (AK, K). WANGANUI: Maungaturuturu, Maunganui-a-te-a, *Attwood s.n.* (AK).

Vernacular name: Kirk's Pittosporum.

24. *PITTOSPORUM REVOLUTUM* Aiton, Hort. Kew. ed. 2. 2: 27. 1811. (T.: ex Hort. Kew.!).

Pittosporum fulvum Rudge, in Trans. Linn. Soc. Lond. 10: 298. t. 20. 1811. (T.: R. Brown s.n.!—The type sheet at B.M. is marked "1. New Holland. Fleming").

Pittosporum tomentosum Bonpl. Descr. Pl. Rar. Malm. p.56. t.21. 1813. (T.: Bonpland s.n.!).

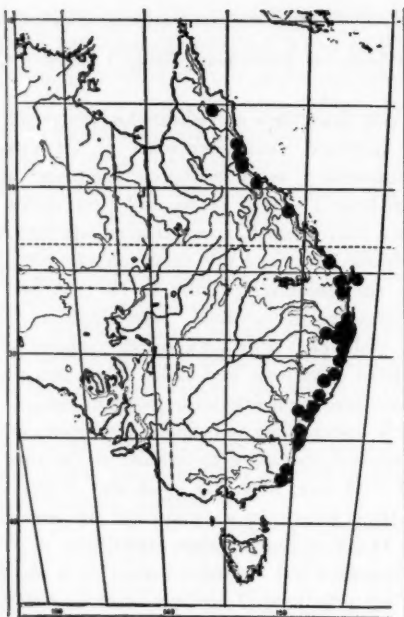
Pittosporum hirsutum Link, Enum. Hort. Berol. 1: 233. 1821, *ex char.* (T.: *ex Hort. Berol.*).

Pittosporum revolutum Aiton var. *tomentosum* (Bonpl.) Bailey in Queensland Agr. Jour. 28: 195. 1912.

Shrubs to 3 m. tall; branchlets grayish-brown, rusty-tomentose when young, glabrescent. Leaves alternate, usually crowded at the tips of the branchlets, elliptic-ovate to elliptic-oblong, acute to shortly acuminate at apex, attenuate at base, entire, 4 - 19 cm. long, 2 - 7 cm. broad, dull green above, glabrate or covered with fine appressed red hairs beneath, subcoriaceous, margins thickened and revolute, occasionally undulate, costa and side veins sunken above, raised beneath, side veins 4 - 10 per side, anastomosing; petioles 5 - 18 mm. long, 1 - 2 mm. broad, rusty-tomentose. Inflorescences terminal, rarely axillary, 1- to 11-flowered, cymose-umbelliform; peduncles brown-tomentose, subtended by several leaves and a whorl of persistent tomentose bud scales 2 - 5 mm. long. Sepals slightly imbricate at base, lanceolate, acuminate with recurved tips, 4 - 8 mm. long, 1.5 - 3.0 mm. broad, sparsely tomentulose and ciliolate, glabrate; petals linear-oblong to linear and pandurate, spreading to reflexed at the tips, obtuse to subacute at apex, clawed, 12.5 - 18 mm. long, 2.5 - 5.0 mm. broad, connivent from the base for two-thirds their length in a cylindrical or somewhat urceolate tube, yellow; stamens 6.4 - 12.0 mm. long, anthers sagittiform to oblong, 1.9 - 4.0 mm. long, 0.5 - 1.5 mm. broad. Pistil at anthesis equal to or slightly longer than the stamens; ovary 3.5 - 6.0 mm. long, 2 - 4 mm. broad, tomentose; style 3.5 - 7.0 mm. long; stigma capitate and obscurely 2- to 4-lobed. Capsules ellipsoid to subglobose, 4- to 6-lobed, 2- to 4-valved, apiculate, 1.5 - 2.8 cm. long, 1.1 - 2.1 cm. broad, green to brown, coarsely rugose, tomentose or glabrate; valves convex to sulcate in transverse section, 2 - 3 mm. thick, woody, with a placenta bearing peg-like funicles up to 4 mm. long from the base to near the apex; seeds 20 - 76, red to reddish-brown, round to irregular.

Occurs from northern Queensland to Victoria, Australia. Flowers from July to October, earlier in Queensland, later in New South Wales and Victoria.

AUSTRALIA: QUEENSLAND: Dalrymple Heights, South Kennedy District, *Clemens s.n.* (BRI); common in rain forest, 600 m., Scrubby Creek, Herberton Range, *White 1370* (A, BRI); Clump Point, via El-Arish, *Fenby s.n.* (BRI); Stony Creek, Rockingham Bay, *Dallachy s.n.* (F, MEL, MO); Herbert River, *Eaton s.n.* (BRI); Cleveland Bay, *Daintree s.n.* (MEL); Port Mackay, *Mueller s.n.* (MEL); creek alluvium, Rosedale, *Dovey 55* (BRI); Pialba, *White s.n.* (A, BRI); in scrub in sandy valley, Fraser Island, *Hubbard 4466* (BRI, K); same locality, *Petrie 120* (BRI); Wide Bay, *Eaves s.n.* (MEL); same locality, *Bidwill s.n.*, 89 (K); Cootharaba, Wide Bay district, *Francis s.n.* (BRI); Lagoon Pocket, via Gympie, *Lowe 14* (BRI) Gympie, *Kenny s.n.* (BRI); Noosa Heads, *Longman s.n.* (K); Eumundi, *Bailey & Simmonds s.n.* (BRI); on bank of creek in cleared rain-forest country, Mudgeeraba, *Hubbard 4180* (K); Moreton Bay, *without collector s.n.* (GH, U); same locality, *Mueller s.n.* (K); Brisbane River, *Dietrich s.n.* (BM, BRI, ILL, MO); *Goodna* scrubs, *Longman s.n.* (K); in dense shade in "scrub" along banks of Pullen Creek, in alluvium, near Riverview, *Hubbard 4815* (K); in heavy soil, bank of Coomera River, Oxenford, S. of Brisbane, ca. 10', *Hubbard 3701* (A, BM, BRI, K); Curumbin, *Longman s.n.* (K); brown loam, rain forest, 3000', Springbrook, Macpherson

Fig. 29. *P. revolutum*.

Range, Hubbard 4278 (A, BM, BRI, K); at edge of rain forest, ca. 2000', Canungra Creek, Lamington National Park, Goy & Smith 142 (BRI); at edges of lower rain forest, 1800', Nixon's Creek Valley, Macpherson Range, Johnson s.n. (NSW); edges of scrub, ca. 2000', Macpherson Range, Bailey s.n. (BRI); Tambourine Mt., Longman & White s.n. (BRI); Point Danger, Schneider s.n. (BRI); Mt. Lindsay, border Queensland and New South Wales, White s.n. (A). NEW SOUTH WALES: Tweed, Guilfoyle s.n. (MEL); Brunswick River, Maiden & Boorman s.n. (NSW); Stanthorpe, Davidson 158 (BRI); Richmond River, Prime s.n. (MO); same locality, Henderson 20 (MEL); same locality, Simmonds s.n. (BRI); same locality, Fawcett s.n. (MEL); same locality, Hodgkinson s.n. (MEL); same locality, Goat Island, Cheel s.n. (NSW); Lismore, in scrub on river bank, Tanner 8 (NSW); Ballina, Baeunton s.n. (A); Clarence River, Mueller s.n. (BM); same locality, Beckler s.n. (MEL); same locality, Woodford Island, Hadley s.n. (NSW); New England, Stuart s.n. (MEL); Coffs Harbour, Boorman s.n. (BISH, NSW); MacLeay River, Beckler s.n. (MEL); Hastings River, Mueller (U); Gloucester Buckets, Maiden s.n. (NSW); same locality, bush at foot of Buckets, Gregson s.n. (NSW); Upper Williams River, Fraser & Vickery s.n. (NSW); same locality, undergrowth in brush forest, White 11474 (A, BRI); Bulahdelah District, Forestry Officer 20 (NSW); banks of Hunter's, William's and Paterson's rivers, Brown 5450 (BM); Hunter's River, Brown 5450 (BM, K); Box Point to Kangaroo River, Maiden s.n. (NSW); shaded woods on the coast, Illawarra District, Port Jackson, Cardunnee, A. Cunningham 18 (BM, K); Port Jackson, R. Brown s.n., 5450 (BM, K, MO); same locality, Canfield s.n. (BISH, US); same locality, Carey s.n. (GH, K); prope Sydney, Anderson 21 (BM); Manly, Helms s.n. (NSW); Cronulla, Steenbohm s.n. (NSW); near Sydney, Betsche s.n. (NSW); Paramatta, Caley s.n. (A); Nelson's Bay, Boorman s.n. (US); Hurstville, Canfield s.n. (US); Mt. Kembla, Hamilton s.n. (NSW); Blue Mountains, Atkinson 53 (MEL); same locality, Erskine Bend, White

695 (NSW); Nepean River, *without collector s.n.* (K); River Grose, *Brown 5450* (BM); Grose Vale, *Vickery s.n.* (NSW); Liverpool, *Moore s.n.* (BM); Bulli Pass Road, *Carne & Hudson s.n.* (NSW); Cambewarra, *Rodway 871* (K); near Nowra, *Barnard 109* (CANB); same locality, *Rodway 912* (K); Bomaderry, *Rodway 1294* (K); Comerong Island, Shoalhaven River, *Rodway 875* (BISH, K); Naval College Road, in wet hollow, Jervis Bay, *Rodway 1954* (K); Twofold Bay, *Mueller s.n.* (MEL). VICTORIA: Genoa River, *without collector s.n.* (MEL). WITHOUT LOCALITY: N. S. Wales, *Fraser s.n.* (A), 114, 115 (BM); N. S. Wales, *Caley s.n.* (A, BM); N. S. Wales, *A. Cunningham s.n.* (K); cote meridionale, *Baudin s.n.* (P); *A. Cunningham 248, 249, 265* (U); *Fleming 1* (BM); *Macarthur s.n.* (K). CULTIVATED: Jardin de la Malmaison, *Bonpland s.n.* (P), ex *Hort. Kew s.n.* (BM).

Pittosporum birtum (Willd. Enum. Hort. Berol. p. 261. 1809) is sometimes cited as a synonym of *P. revolutum* Ait. but I have not seen specimens and the home of the plant is given by Willdenow as the Canary Islands.

Pittosporum revolutum is not common in cultivation but I have seen specimens from Italian, Californian, and Australian gardens. The leaves of specimens from New South Wales are frequently much smaller than those from Queensland, but the extremes are connected by numerous intermediates and I am unable to recognize distinct forms.

Vernacular names: Wild Yellow Jasmine (Lagoon Pocket, *Lowe 14*); Yellow-flowered Brisbane Laurel; Genoa Pittosporum (Victoria).

25. PITTOSPORUM RUBIGINOSUM A. Cunn. in Ann. Nat. Hist. 4: 108. 1839. (T.: *A. Cunningham s.n.*!).

Pittosporum wingii F. Muell. in South. Sci. Rec. n.s. 1: 49. March 1885. (T.: *Dallachy s.n.*!).

Shrubs 1.5 - 6.0 meters tall, branchlets brown and rusty-tomentose. Leaves basically alternate but rather irregularly subverticillate, elliptic to lanceolate or oblanceolate, acutely acuminate to cuspidate at apex, attenuate at base, entire, 6.0 - 33.5 cm. long, 2.5 - 13.0 cm. broad, dark green above, pale green to reddish-purple beneath, sparsely tomentose to glabrescent above, sparsely to densely tomentose beneath, especially on the veins, the hairs dark red and erect, membranous, margins flat or sometimes irregularly revolute, costa and secondary veins sunken above, raised beneath, rusty-tomentose, secondary veins 8 - 13 per side, anastomosing; petioles 2.5 - 12.0 mm. long, 1 - 2 mm. broad, tomentose. Inflorescences variable, consisting of a shoot 4.0 - 11.5 cm. long, red-tomentose, subtended by a whorl of leaves and bud scales and a sequence of cataphylls which become foliar above, sometimes producing 1 to several solitary flowers in the axils of the uppermost cataphylls and sometimes being terminal, 3- to 32-flowered, umbelliform; peduncles and pedicels red-tomentose, accrescent in fruit, subtended by numerous caducous foliar to scarious bracts. Sepals free or slightly imbricate at base, linear-lanceolate, acute to acuminate with recurved tips, sparsely ciliate with scattered hairs to densely ciliate, tomentose, 4.0 - 8.5 mm. long, 1 - 2 mm. broad; petals oblanceolate to linear-oblong, sometimes pandurate, obtuse to sub-acute, 11 - 17 mm. long, 2 - 4 mm. broad, coherent from the base to the middle in

a somewhat urceolate to spreading tube, or free and patent; stamens 4.5 - 11.5 mm. long; anthers sagittiform to ovate-elliptic, 1.0 - 3.5 mm. long, 0.5 - 1.0 mm. broad. Pistil at anthesis slightly shorter or longer than the stamens; ovary 2.0 - 5.5 mm. long, 1 - 3 mm. broad, villous; style 3.5 - 6.5 mm. long; stigma capitate and obscurely 2- or 4-lobed or truncate. Capsules ellipsoid to ovoid, 2-, or rarely 3-, valved, 1.3 - 2.1 cm. long, 6 - 15 mm. broad, with an evident stipe 0.5 - 4.0 mm. long, yellow to orange, densely to sparsely rusty-tomentose or glabrate, minutely rugose; valves convex to slightly sulcate in transverse section, less than 1 mm. thick, coriaceous, with a placenta thickened at the base and bearing peg-like flattened funicles up to 2.5 mm. long from the base to about the middle; seeds 3 - 14, dark rusty-red to red, irregular.

KEY TO THE SUBSPECIES

- Shrubs 1.5-2.5 m. tall; leaves sparsely rusty-tomentose to glabrate beneath; sepals sparsely ciliate with scattered hairs; petals coherent to the middle in a somewhat urceolate or cylindrical tube, linear-oblong, sometimes pandurate; stamens 6.0-11.5 mm. long; anthers 1-3 mm. long; capsules sparsely rusty-tomentose to glabrate. Queensland: Cooktown to south of Cairns.....25a. *P. r. rubiginosum*
- Shrubs to 6 m. tall; leaves densely rusty-tomentose beneath; sepals densely ciliate and rusty-tomentose; petals coherent to the middle in a spreading tube, linear-oblong to oblanceolate; stamens 4.5-11.0 mm. long; anthers 1.5-3.5 mm. long; capsules densely rusty-tomentose. Queensland: Atherton Tableland to Rockingham Bay.....25b. *P. r. wingii*

25a. *PITTOSPORUM RUBIGINOSUM* ssp. *rubiginosum*

Known from Cooktown to south of Cairns, Queensland, from near sea-level to 1650 m. Flowers from July to September.

AUSTRALIA: QUEENSLAND: summit of Mt. Cook, Endeavour River, *A. Cunningham* 26 (BM, MO); shaded woods on the sides of Mt. Cook, *A. Cunningham* 26 (K); Cooktown, *Rose* 109 (MEL, NSW); Mossman River, *Sayer* 186 (MEL); same locality, *Lucas s.n.* (MEL); in hillside forest in the lowlands, Daintree River, *Brass & White* 279 (BRI); in rain forest, Daintree, Cook District, *Blake* 14996 (BRI); same locality, *Brass* 2220 (A, BRI); in rain forest, 2500', Mt. Dimi, *Brass* 2090 (A, BISH, BRI, K); very common in rain forest, about 4000', Thornton Peak, *White & Brass* 227 (A, BRI, K); very common in rain forest, Mt. Spurgeon, *White* 10618 (A, BM, BRI); Trinity Bay Range, *Bailey s.n.* (AK, BRI, K); same locality, *Fitzalan s.n.* (GH); Cairns, *Bailey s.n.* (NSW); same locality, *Fitzalan* 77 (MEL); in rocky soil, light scrub, creek bank, Clark's Creek, near Cairns, *Toogood* 9 (BRI); Freshwater Creek near Cairns, *Francis s.n.* (BRI, K); same locality, *Cowley* 56 (K); in rain forest, ca. 100', at The Intake, near Cairns, *Blake* 14982 (BRI); 2000'-3000', Mt. Bellendenker, *Cabbage* 3821 (NSW); 4000'-5000', same locality, *Sayer s.n.* (MEL); same locality, *White* 1255 (A, BRI, NSW, US); same locality, *Bailey* 20 (BRI, K); in rain forest and montane forest, 3000' - 5000', Mt. Bartle Frere, North Peak, W. and N.W. slope, *Blake* 15242 (BRI); Russell River, *Johnson s.n.* (MEL); Johnstone River, *Michael* 9, 30, 117 (BRI); same locality, *Bancroft s.n.* (BRI, K); State Forest Reserve 185, Danbulla, *Doggrell A.S.* (BRI); Mt. Alexandra, *Bailey* 13 (BRI).

Specimens collected near sea-level have leaves much longer than those from high elevations; e.g. *Brass & White* 279 from lowlands near the Daintree River has leaves 19 cm. long and 6.5 cm. broad, and *Blake* 14982 from 100' above sea-level at The Intake, near Cairns, has leaves up to 20 cm. long and 6.5 cm. broad. *Brass* 2090 from 2500' on Mt. Dimi has leaves up to 11.5 cm. long and 3 cm. broad, and *White & Brass* 227, from about 4000' on Thornton Peak, has leaves up

to 10 cm. long and 4 cm. broad. Changes in leaf size are gradual and I cannot define distinct forms.

The flower parts also vary in size. Flowers which may be female have capitate and obscurely 2-lobed stigmas, styles 4 - 5 mm. long, plump ovaries 4.0 - 5.5 mm. long, 3 - 4 mm. broad, short stout filaments 4 - 6 mm. long, probably abortive sagittiform anthers 1 - 2 mm. long, and an almost urceolate corolla-tube from which the stigma is exerted. Flowers which may be male have truncate stigmas, styles 5.0 - 6.5 mm. long, slender ovaries 2.0 - 4.5 mm. long, 1 - 2 mm. broad, slender filaments 6 - 9 mm. long, probably functional ovate-elliptic anthers 2.5 - 3.0 mm. long, and a tubular corolla in which the stigma is included. Flower color is described as "white tinged with cream" (Blake 14982), and "yellow, paler toward the base" (Blake 15242).

Vernacular name: Rusty Pittosporum.



Fig. 30. *P. rubiginosum* ssp. *rubiginosum* and ssp. *wingii*.

25b. *PITTOSPORUM RUBIGINOSUM* ssp. *wingii* (F. Muell.) R. C. Cooper, *stat. nov.*

Pittosporum wingii F. Muell. in South. Sci. Rec. n.s. 1: 49. March 1885. (T.:Dallachy s.n. !).

Known from the Atherton Tableland to Rockingham Bay, Queensland. Flowers in September.

AUSTRALIA: QUEENSLAND: top of the Coast Range, under the rocks, Rockingham Bay, *Dallachy s.n.* (GH, K, MEL MO); 800 m., Lake Barrine, Atherton Tableland, *Kajewski 1341* (A, BRI, K, MEL, NSW).

Variation in flower size and form has also been found in this variety. The Rockingham Bay flowers have truncate stigmas, styles 5 mm. long, ovaries 3 - 4 mm. long, 2.5 - 3.0 mm. broad, filaments 5 - 7 mm. long, and probably functional anthers 3.0 - 3.5 mm. long. The sepals are 7.5 - 9 mm. long, and the petals 13 mm. long. The Atherton Tableland flowers have 4-lobed stigmas, styles 3 - 4 mm. long, ovaries 3.5 - 4.0 mm. long, 2.5 - 3.5 mm. broad, filaments 3 - 4 mm. long, and apparently abortive anthers only 1.5 - 2.0 mm. long. In one flower two large functional anthers and three small aborted anthers were found. The sepals are 5 - 9 mm. long, and the petals 9 - 11 mm. long. It is possible that the Rockingham Bay flowers have been collected at a later stage in development than those from Atherton Tableland, but the slender ovaries, larger styles, truncate stigmas, and functional anthers of the former suggest that the flowers are male, while the plumper ovaries, shorter capitate stigmas, and apparently abortive anthers of the latter suggest that the flowers are female.

26. *PITTOSPORUM UNDULATUM* Vent. Descr. Pl. Nouv. Jard. Cels, t. 76. [1802]¹⁷⁰ *ex char. & icon.*

Shrubs or trees 5 - 13 m. tall; branchlets gray, the young parts tomentose, soon glabrate. Leaves alternate, elliptic-oblong to oblanceolate, acuminate at apex, attenuate at base, entire, 6 - 16 cm. long, 1.5 - 5.0 cm. broad, green above, paler beneath, tomentulose when young, glabrate, membranous, margins undulate or flat, sometimes recurved, costa sunken or raised above, raised below,*secondary nerves about 12 per side, anastomosing, distinct; petioles 7 - 26 mm. long, 1 - 2 mm. broad, tomentulose when young, glabrate. Inflorescences terminal, 4- to 15-flowered, subumbelliform; peduncles and pedicels 1.9 - 3.1 cm. long, accrescent in fruit, tomentose; peduncles subtended by a whorl of leaves and numerous caducous, brown-tomentose, ciliolate bud scales 1 - 2 mm. long. Sepals frequently connate in a tube which splits into 2 parts, one 1- to 2-lobed, the other 3- to 4-lobed, lanceolate, acuminate, 6.5 - 10.5 mm. long, 1.2 - 2.5 mm. broad, tomentulose, falling before the petals; petals linear-oblanceolate to linear-oblong, obtuse, 11 - 17 mm. long, 3 - 4 mm. broad, coherent at the base, spreading to recurved above, white; stamens 5 - 11 mm. long, sometimes reduced to sterile rudiments 0.5 - 1.0 mm. long; anthers lanceolate-oblong to sagittiform, 2.5 - 5.0 mm. long, 1.0 - 1.5 mm. broad. Pistil at anthesis slightly shorter or longer than the stamens; ovary 4 - 6 mm. long, 1.8 - 4.0 mm. broad, tomentulose; style 2.0 - 4.5 mm. long; stigma capitate and obscurely 2- to 4-lobed or almost truncate. Capsules subglobose, 2-valved, 10 - 14 mm. in diameter, yellow to brown, smooth to slightly rugose, glabrous; valves convex in transverse section, less than 1 mm. thick,

¹⁷⁰ W. T. Stearn (Jour. Soc. Bibl. Nat. Hist. 1:199-201. 1939) gives the dates of publication of this work as 1800-1802, t. 76 being published in 1802.

coriaceous, with a placenta thickened at the base and bearing 2 - 3 rows of short stout peg-like funicles from the base to just above the middle; seeds 12 - 22, red to dark red or black, irregular.

Occurs from the Macpherson Range, in southern Queensland, to the Victorian Alps, along the ranges of New South Wales. Flowers in August and September.

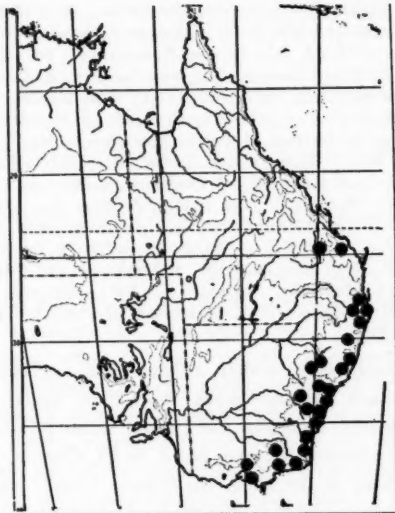


Fig. 31. *P. undulatum*.

AUSTRALIA: QUEENSLAND: Bunya Mts., *Bailey s.n.* (BRI, NSW); same locality, *White s.n.* (BRI); same locality, *Moulday s.n.* (BRI); 2800', at edge of scrub in partial shade, Mount Mistake, *Hubbard 5225* (A, K); same locality, *Shirley s.n.* (A); Eumundi, *Simmonds s.n.* (A); Moreton Bay, *without collector s.n.* (U); moderately common in light rain forest, sandy soil, Southport, *White 9206* (A, BH, BRI); Tambourine Mountain, *Shirley s.n.* (NSW); same locality, *Longman & White s.n.* (BRI); same locality, *White 3570* (BRI); same locality, *Simmonds s.n.* (A); near Canungra, *Brass s.n.* (NSW); Lamington N. Park, *Moore s.n.* (BRI); Beechmont, *White 6179* (BRI); Acacia Creek via Killarney, *Dunn 129* (NSW); near Emu Vale, Macpherson Range, *Francis s.n.* (BRI); Cunningham's Gap, *Bailey s.n.* (BRI); on Rhyolite at edge of rain forest in wet sclerophyll forest, ca. 2400', Nixon's Creek, Upper Falls, Macpherson Range, *Johnson 106* (NSW). NEW SOUTH WALES: 3000', in bush, Waterfall Creek, Mt. Wilson, *Johnson s.n.* (NSW); Tiba Tilba, *Bate 94* (MEL) near Tentfield, *Stuart s.n.* (K); Conjola, *Heron s.n.* (NSW); Lismore, *Maiden 17* (U); New England, *Stuart s.n.* (MEL); in bed of creek, ca. 20 miles N.N.E. of Boggabi, towards Nandewar Range, *Swain s.n.* (NSW); Barraba, *Kifford s.n.* (NSW); Hastings River, *Beckler s.n.* (MEL, U); Gloucester Buckets, *Maiden s.n.* (A, NSW); Rylstone, *Baker s.n.* (A); ca. 1000', Macquarie Pass, Robertson to Albion Park, *Johnson s.n.* (NSW); banks of River Grose, first branch, *Brown 5451* (BM); Kurradjong, adjacent to the River Grose, *Atkinson s.n.* (MEL); occasional in gullies on granite, 690 m., Ruby Creek, Mt. Werong, ca. 30 miles south of Oberon, *Johnson & Constable s.n.* (K, NSW); upper Chichester River, *Fraser & Vickery s.n.* (A, BISH, BH, MO, NSW, US); on old sand dunes, peninsula north of the entrance to Tuggerah, via

Wyong, *Helms* 582 (A); Box Point to Barber's Creek, *Maiden* s.n. (K, NSW); in shaded woods on the sea-coast, Illawarra, Port Jackson, *A. Cunningham* s.n. (K); shores of Port Jackson, *Brown* 5451 (BM); Port Jackson District, *Brown* 5451 (K, MO); same locality, *Siemssen* 97 (MEL); same locality, *Steel* s.n. (NSW); same locality, *Helms* s.n. (BRI); same locality, *Camsfield* s.n. (MO); near Sydney, *Weber* s.n. (NSW); Cheltenham, *Johnson* s.n. (NSW); Petersham, *Steel* s.n. (AK); Sydney, *Haswell* s.n. (BRI); same locality, *Backhouse* s.n. (BM); same locality, *Wilkes* s.n. (K, US); same locality, *McWilliams* s.n. (K); same locality, *Verreaux* 406 (K); Illawarra, *Macarthur* 26 (K); Berry Mountain, *Maiden* s.n. (NSW); Sugar Loaf Mountain, Braidwood, *Baennton* s.n. (MEL, NSW); Queanbeyan, *Breakwell* s.n. (NSW); 1200', between Nowra and Kangaroo Valley, Cambewarra Range, *Rodway* 1690 (A, K); Nowra, *Rodway* 361, 847 (K); Shoalhaven River, Wingello, *Murphy* 9 (NSW); Comerong Is., same locality, *Rodway* 874 (K); Candelo, *White* s.n. (MEL); Twofold Bay, *Father* s.n. (A); same locality, *Mueller* s.n. (MEL). VICTORIA: Genoa River, *Reader* s.n. (MEL); Broadrib, or Broadribb River, *Mueller* s.n. (K, MEL); in rupibus prope Buchan ad flumen Murrandale, *Mueller* s.n. (MEL); Snowy River, *Mueller* s.n. (K, MEL); Stony Creek, *Smith* s.n. (MEL); East Gippsland, *Mueller* s.n. (GH, MEL); Dead-Cock Creek, E. of Lindenow, *Green* s.n. (MEL); in small steep gully above sea cliff, Mt. Martha, E. Port Phillip, *Johnson* s.n. (NSW); in moist sandstone gully, Epping, *Ford* s.n. (NSW); Wilson's property, near Korumburra, *Strzlecki* Ranges, *without collector* s.n. (MEL). WITHOUT DEFINITE LOCALITY: Australia, *Verreaux* 48 (BM), 44P (P, US); East Australia, *Schomburgk* s.n. (MEL); South Australia, *Schomburgk* s.n. (NSW); Australia, *Lhotsky* s.n. (BM); Australia, *Sieber* 221 (A, BM, ILL, K, MEL, MO); N. S. Wales, *A. Cunningham* or *Anderson* and others 321 (U); N. S. Wales, *Caley* s.n. (BM).

Pittosporum undulatum is widely cultivated as an ornamental, hedge, or shelter plant, and I have seen specimens from New Zealand, Australia, Chile, Colombia, Bolivia, Jamaica, Bermuda, the United States (California and Florida), the Azores, the Canary Islands, France, Israel, India, Ceylon, China, and Hawaii. It has become naturalized in Bermuda, the Canary Islands and Hawaii. A form with variegated leaves is available in the trade in Australia,¹⁷¹ and a small-leaved plant, labelled "*Pittosporum* hybrid," and "a glabrous-leaved form of *P. bicolor*" have been collected from the Strzlecki Ranges, Victoria, (*without collector* s.n. MEL) and from South Australia (*Schomburgk* s.n. NSW). The last form is connected with the large-leaved plants by intermediates, and I am unable to recognize it as a distinct variety. According to Bentham,¹⁷² the height of *P. undulatum* is "about 40 feet, or according to M'Arthur 60 to 90 feet". Recent collectings are from smaller trees, but a plant at East Alameda Plaza, Santa Barbara, California, is stated to be about 60 feet tall and 50 feet in crown diameter (*Moran* 2349 BH), so it is possible that trees of 60 to 90 feet were found in the early days of Australian botany.

The variation in the morphology of the flower has been described and illustrated by Maiden,¹⁷³ Gowda,¹⁷⁴ and Cufodontis.¹⁷⁵ Flowers which may be female

¹⁷¹ *Pittosporum undulatum* "variegatum", commonly known as the Variegated Sweet Pittosporum (Lord, Shrubs and Trees for Australian Gardens. p.34. 1948).

¹⁷² Fl. Austr. 1:111. 1863.

¹⁷³ For. Fl. N.S.W. 7:124. 1920.

¹⁷⁴ Jour. Arnold Arb. 32:276. 1951.

¹⁷⁵ Österr. Bot. Zeitschr. 98:114. 1951.

have capitate obscurely lobed stigmas, styles 2 - 3 mm. long, and ovaries 4.0 - 4.5 mm. long and 2 - 3 mm. broad. The stamens are rudimentary, gland-like structures 0.6 - 1 mm. long. Flowers which may be male or bisexual have weakly capitate to truncate stigmas, styles 3.0 - 4.5 mm. long, ovaries 3.5 - 5.0 mm. long, 1.5 - 2.0 mm. broad, stamens 8.5 - 11.0 mm. long, and functional anthers 3.5 - 5.0 mm. long and 1.0 - 1.5 mm. broad. Intermediate forms occur in which the stamens are reduced, the most remarkable being *Ford s.n.* in which the stamens vary in length from 5 - 7 mm. in the same flower. Flowers also occur with 1 - 2 extra sepal lobes, and petals.

Vernacular names: Wave-leaved Pittosporum, Cheesewood, Engraver's wood, New South Wales Box Tree, New South Wales Mock Orange, Native Laurel, Victorian Laurel, Sweet Pittosporum (Victoria), *Wallundundeyren*, *Bart-Barb* (Aboriginal).

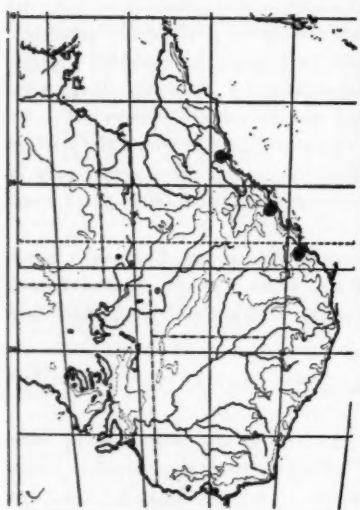
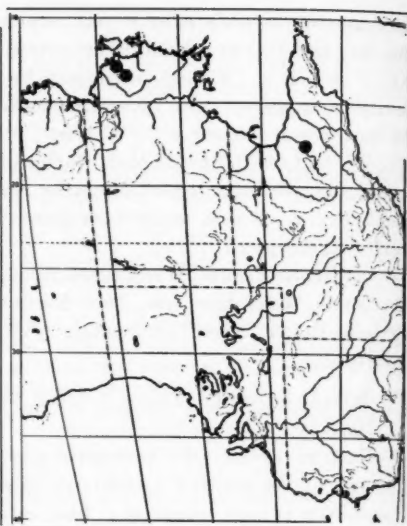
27. *PITTOSPORUM VENULOSUM* F. Muell. Frag. Phyt. Austr. 6: 186. 1868. (T.: *Dallachy s.n.*!).

Trees to 10 m. tall; branchlets gray, rusty-tomentose when young, soon glabrate. Leaves alternate to subverticillate, lanceolate to ovate-lanceolate, acute to acuminate at apex, attenuate at base, entire, 4.5 - 10.5 cm. long, 1.7 - 4.2 cm. broad, rusty-tomentose when young, especially on costa, glabrate, coriaceous, margins undulate, irregularly revolute, costa immersed or sunken above, raised below, secondary veins 8 - 12 per side, anastomosing, distinct; petioles 6 - 21 mm. long, 1 - 1.5 mm. broad, rusty-tomentose when young, soon glabrate. Flowers terminal, in umbelliform cymes; peduncles subtended by a loose whorl of leaves and by numerous caducous rusty-tomentose bud scales 2 - 6 mm. long; peduncles and pedicels accrescent in fruit, rusty-tomentose, soon glabrate. Sepals not imbricate, oblong, obtuse, 4.0 - 4.5 mm. long, 1.5 - 2.0 mm. broad, ciliate, rusty-tomentose without, glabrous within; petals oblong, obtuse, 8 - 11 mm. long, 1.5 - 2.0 mm. broad, free, spreading at the tips, white; stamens 4 - 5 mm. long, anthers sagittiform, 2.0 - 2.5 mm. long, 0.5 - 1.0 mm. broad. Pistil at anthesis longer than the stamens; ovary 4.0 - 4.5 mm. long, 2 mm. broad, rusty-tomentose; style 1.5 - 2.0 mm. long; stigma capitate, obscurely 4-lobed. Capsules subglobose to obovoid with an evident stipe, 2-, rarely 3-, valved, apiculate, 1 - 2 cm. long, 1.0 - 1.4 cm. broad, glabrate, rugose; valves convex in transverse section, 1 - 2 mm. thick, woody, with placentas much thickened and fused at the base, bearing 6 - 8 peg-like funicles up to 2 mm. long about the middle; seeds 6 - 14 per capsule, reddish-black to black, irregular.

Occurs in the coastal ranges of Queensland, between Rockingham Bay and Keppel Bay.

AUSTRALIA: QUEENSLAND: Coast Range, at edge of scrub, Rockingham Bay, *Dallachy s.n.* (BM, K, MEL, NSW); Eungella Range, *Francis s.n.* (BRI, MEL); rare, at edge of light rain forest on rather steep hillsides, Byfield near Keppel Bay, *White 8142* (A, BRI); Mt. Spec, *White 8974* (A, BH).

I have not seen adequate flowering material and have described the inflorescence from immature specimens.

Fig. 32. *P. venulosum*.Fig. 33. *P. melanospermum*.

28. *PITTOSPORUM MELANOSPERMUM* F. Muell. Frag. Phyt. Austr. 1: 70. 1859. (T.: Holt s.n. !)

Pittosporum setigerum Bailey, in Queensland Agr. Jour. 1: 451. 1897. (T.: Barclay-Millar s.n. !).

Pittosporum muticum Domin, in Bibliog. Bot. 22: 718. 1925. (T.: Schultz 758 !).

Shrubs or small trees to 6 m. tall; branchlets reddish-gray, glabrous. Leaves alternate, sometimes crowded, oblanceolate to oblong, rarely obovate, obtuse to acuminate or mucronate at apex, attenuate at base, entire, 4 - 14 cm. long, 1.1 - 4.5 cm. broad, glabrous, coriaceous, margins thick, flat to slightly undulate, costa immersed above, raised below, secondary veins 13 - 18 per side, anastomosing, raised on both surfaces; petioles 1.4 - 4.0 cm. long, 1 mm. broad, glabrous. Flowers terminal, very numerous, in spreading paniculiform cymes; peduncles subtended by an approximate whorl of 3 - 4 leaves and minute caducous bud scales, and bearing branches which are subtended by caducous cataphylls, and which are again divided, the ultimate divisions each bearing several pedicels; peduncles, branches, and pedicels accrescent in fruit, white-tomentulose, soon glabrate. Sepals slightly imbricate to coherent in a shallow cup, ovate, subacute to acute, 1.5 - 2.5 mm. long, 1 - 2 mm. broad, white-tomentulose becoming glabrate; petals obovate to lorate, obtuse, 7 - 9 mm. long, 2.0 - 3.5 mm. broad, free, patent, yellow; stamens 6.5 - 10.5 mm. long, anthers elliptic-ovate, 1.5 - 2.0 mm. long, up to 1 mm. broad. Pistil at anthesis slightly shorter than the stamens; ovary 2.5 - 3.5 mm. long, 0.5 - 2.0 mm. broad, white-tomentulose, on a glabrous stipe about 1 mm. long; style about 1.5 mm. long; stigma truncate. Capsules obovoid to subglobose, 2-

valved, apiculate, 6 - 15 mm. in diameter, frequently with a stipe 0.5 - 1.5 mm. long, glabrate, brownish-yellow; valves convex to sulcate in transverse section, less than 1 mm. thick at sides, coriaceous, with a placenta much thickened at base and apex, and occasionally fused to form 2 chambers, bearing several short stout peg-like funicles between the base and middle; seeds 2 - 6, black, irregular.

Known from northern Queensland and the Northern Territory.

AUSTRALIA: NORTHERN TERRITORY: Arnhem's Land, *Mueller s.n.* (K); north of Arnhem's Land and Port Darwin, *Mueller s.n.* (NSW); Port Darwin, *Holt s.n.* (MEL); same locality, *Schultz 626, 758* (K); McKinlay, North Arnhem's Land, *Jim Millar s.n.* (MEL). QUEENSLAND: Cape York Penins. Expedition, *Hann 98* (K); Walsh River, *Barclay-Millar s.n.* (A, BM, BRI, K); common in rain forest, 500 m., Lake Barrine, Atherton Tableland, *Kajewski 1352* (A, BRI, P).

29. *PITTOSPORUM RHOMBIFOLIUM* A. Cunn. ex Hook. Icon. Pl. 7: *t. 621*. 1844.
(T.: *A Cunningham 29*!).

Trees 13 - 30 m. tall; branchlets light brown, glabrous. Leaves alternate, sometimes crowded at the tips of the branchlets, rhombic to ovate, acuminate to obtuse at apex, attenuate at base, coarsely serrate to entire, 4 - 10 cm. long, 1.5 - 7.0 cm. broad, glabrous, coriaceous, margins frequently flat or revolute, costa sunken above, raised beneath, secondary veins about 12 - 14 per side, anastomosing, raised above and below; petioles 0.9 - 2.7 cm. long, 1 - 2 mm. broad, glabrous. Flowers terminal, many, in spreading umbelliform cymes; peduncles and pedicels up to 5 cm. long, accrescent in fruit, glabrous, peduncles subtended by a single leaf and 1 or 2 minute caducous bud scales. Sepals coherent at base, ovate, acute to subacute, 1.1 - 3.0 mm. long, 0.5 - 2.0 mm. broad, glabrous; petals elliptic to oblanceolate, obtuse to subacute, 5.5 - 8.5 mm. long, 1.5 - 3.0 mm. broad, free, patent, white, with short claws; stamens 5.5 - 8.0 mm. long, anthers lanceolate, 1.7 - 2.4 mm. long, about 1 mm. broad. Pistil at anthesis slightly shorter than the stamens; ovary 3.5 - 4.0 mm. long, 1 - 2 mm. broad, short-stipitate, tomentulose; style 0.5 - 1.0 mm. long; stigma truncate. Capsules subglobose to obovoid, 2-valved, obtuse to apiculate at apex, stipitate at base, 5 - 10 mm. long, 5 - 8 mm. broad, yellow, slightly rugose, glabrous; valves convex to sulcate in transverse section, less than 1 mm. thick, coriaceous, with a conspicuous placenta more or less fused to form 2 chambers and bearing 1 - 2 minute funicles near the base; seeds 1 - 3, black, irregular.

Occurs from northern Queensland to northern New South Wales, Australia. Flowers in November, December and January.

AUSTRALIA: QUEENSLAND: Canaan Valley, near Proserpine, *Michael 973* (BRI, NSW); Tooloom Range, *Maiden s.n.* (NSW); Rockhampton, *Tboxet s.n.* (MEL); same locality, *O'Shanesy 87/9* (MEL); in red, sandy loam, 12 miles east of Emerald, Leichardt District, *Everist 2522* (BRI); in mixed soft-wood forest, Guluguba, Leichardt District, *White 1146* (BRI); between Brisbane and Dawson, *Mueller s.n.* (K); Dawson River, *Mueller s.n.* (MEL); Gladstone, *Bailey s.n.* (NSW); Mt. Perry, *Keys s.n.* (BRI); Eidsvold, *Bancroft s.n.* (BRI); Wallaville, 30 miles s. of Bundaberg, *Bancroft s.n.* (BRI); parish of Woowooyang, Maryborough, *Simon 37* (BRI); Maryborough, *Young s.n.* (BRI, NSW); Wide Bay, *Bidwill 52* (K); in light sub-xerophytic mixed scrub, Roma, *White*

9522 (A, BRI); Yalbone Creek via Rome, *McKenzie s.n.* (BRI); in "ringed" brigalow scrub, Chinchilla, *Beasley 27* (BRI); Blackbutt Range, *Shirley s.n.* (A); Yarraman, *Clemens s.n.* (BRI); Crow's Nest, *Kenny s.n.* (BRI); same locality, *Clemens 43747* (A); Crystal Brook, Bowenville, *Fuller s.n.* (NSW); Moreton Bay, *A. Cunningham s.n.* (GH); Brisbane, *Bailey s.n.* (BRI, NSW); in shaded woods on the banks of the Brisbane River, *A. Cunningham 29* (BM, BRI, K); same locality, *A. Cunningham s.n.* (MEL); same locality, *White s.n.* (NSW); Enoggera, near Brisbane, *Boorman s.n.* (NSW); Ipswich, *Nernst 34* (MEL); Beau-desert, *Brass s.n.* (A); Roberts Plateau, Lamington National Park, *White 6045* (A); Milford, Fassifern District, *Michael 2024* (A, BRI); Beech Mountain, *White 1903* (A, BRI); Acacia Creek, via Killarney, *Dunn 136* (NSW); National Park, *Shirley s.n.* (NSW); in regrowth on rain-forest margin, ca. 3000', O'Reillys, Lamington National Park, *Smith & Webb 3612* (BRI); common in light rain forest, Unumgar, near Mt. Lindesay, NSW-Q border, *White 12507* (BRI). NEW SOUTH WALES: Tweed, *Guilfoyle s.n.* (MEL); Burringbar, *Betche s.n.* (NSW); same locality, *McLean s.n.* (NSW); Lismore, *Baunton s.n.* (A); same locality, *Tanner s.n.* (NSW); same locality, *Maiden s.n.* (U); Richmond River, *Moore s.n.* (GH, K); Possum Shoot, Richmond River, *Watts s.n.* (NSW); Clarence River, *without collector s.n.* (NSW). WITHOUT LOCALITY: *Walter s.n.* (MEL).

The plant is useful as an ornamental tree, and I have seen cultivated specimens from California, Florida, Queensland, New South Wales, and South Australia.

Vernacular names: White Myrtle, Diamond-leaf Laurel, Rhombus-leaved Queensland Laurel, *Burrawingee*.

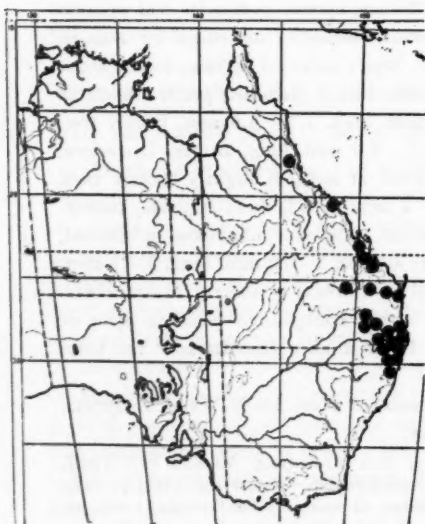


Fig. 34. *P. rhombifolium*.

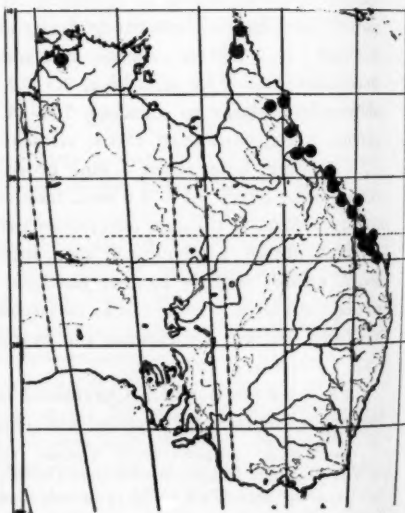


Fig. 35. *P. ferrugineum*.

30. *PITTOSPORUM FERRUGINEUM* Aiton, Hort. Kew. ed.2. 2: 27. 1811. (T.: *ex hort. Kew.* 1).

Pittosporum linifolium A. Cunn. in Ann. Nat. Hist. 4: 109. 1839, as *tinifolium*. (T.: A. Cunningham s.n. 1).

Pittosporum ovatifolium F. Muell. Frag. Phyt. Austr. 2: 78. 1860. (T.: *Dallachy s.n.* 1).

Pittosporum queenslandicum Domin, in Fedde. Repert. Sp. Nov. 11: 201. 1912. (T.: R. Brown 5449 1).

Trees or shrubs 8 - 20 m. tall; branchlets grayish-brown, rusty-tomentose when young, glabrate. Leaves alternate, frequently crowded at the tips of the branchlets, elliptic to elliptic-ovate or obovate, acute to acuminate or occasionally obtuse at apex, attenuate at base, entire, 4.8 - 11.5 cm. long, 2.0 - 5.5 cm. broad, green above, paler beneath, rusty-tomentose when young, soon glabrate except on costa, margins flat or recurved, costa sunken above, raised below, secondary nerves 4 - 8 per side, anastomosing, obscure above, raised beneath; petioles 1.2 - 2.2 cm. long, rusty-tomentose when young, glabrate. Flowers terminal or axillary, many, in subumbelliform cymes; peduncles and pedicels 1.5 - 4.0 cm. long, rusty-tomentose; peduncles subtended by 1 to several leaves and a whorl of ciliate bud scales about 1 cm. long; pedicels subtended by 1 to several caducous bracts 2 - 4 mm. long. Sepals free or coherent at the base, linear to linear-lanceolate, acuminate, 2.5 - 3.5 mm. long, 0.6 - 1.2 mm. broad, sparsely tomentulose and ciliate; petals linear to oblanceolate-linear, 7 - 9 mm. long, 1.2 - 1.5 mm. broad, coherent in a cylindrical tube with recurved tips, yellow; stamens 4.0 - 6.5 mm. long, anthers oblong, 0.5 - 2.0 mm. long, 0.3 - 0.6 mm. broad. Pistil at anthesis slightly shorter or longer than the stamens; ovary 3 - 4 mm. long, 0.8 - 2.0 mm. broad, tomentulose; style 1.2 - 2.0 mm. long; stigma capitate and 2-lobed to almost truncate. Capsules globose, 2-valved, about 7 - 10 mm. in diameter, slightly rugose, glabrous; valves convex in transverse section, less than 1 mm. thick, coriaceous, with a placenta thickened at the base, bearing 2 rows of short, stout, peg-like funicles from the base to just above the middle; seeds 15 - 16, black, irregular.

Occurs mainly on the coast, from Cape York to Rosedale, Queensland; also found in Malaysia from the Solomon to the Nicobar Islands. Flowers in Australia from June to August.

AUSTRALIA: NORTHERN TERRITORY: Adelaide River, *Lea s.n.* (BM); QUEENSLAND: Albany Island, *Hill 12, 13* (K); same locality, on dry ridges, *Mueller s.n.* (K); Cape York Peninsula Expedition, *Hann 366* (K); Cape York, *Ramsay s.n.* (NSW); same locality, *Daemel s.n.* (BM, GH, K, MEL, US); Vrilya Point, *J. F. Bailey s.n.* (BRI); on banks of the Endeavour River, *A. Cunningham 27, 117* (BM); Endeavour Ridge, at some distance from the sea, *A. Cunningham s.n.* (K), 27 (MO), 117 (BM, BRI, K); same locality, *Perich 4* (MEL); common along creek banks in rain forest, Mossman, *Blake 15014* (BRI, MEL); same locality, *Sayer s.n.* (BM); botanic reserve, Cairns, *White 10560* (BRI, MEL); Cape Grafton, *A. Cunningham 8* (K); sterile sands of Fitzroy Island, near Cape Grafton, *A. Cunningham 116* (K), *s.n.*, 116 (BM); Frankland Isles, *MacGillivray 1* (K); Rockingham Bay, *Dallachy s.n.* (BM, F, GH, MEL, MO, U); same locality, *Bailey s.n.* (BRI, K); Cardwell, *Bailey s.n.* (BRI, K); Palm Island, *J. B. [Banks & Solander] s.n.* (BM); same locality, *Simmonds s.n.* (BRI); same locality, *Bancroft s.n.* (BRI); Sandy Cape and Port Bowen, *MacGillivray 105* (BM); Palm Creek, Proserpine, *Michael 1484* (BRI), *s.n.* (K); Pioneer River, Mackay, *Griffiths s.n.* (MEL, NSW); Port Mackay, *Dietrich 370*,

1299 (MEL); scrub, Pilot Station, Mackay, *Griffiths s.n.* (BM, BRI); in rocky water-gullies, and in thickets on the hills, Percy Island, *A. Cunningham s.n.* (K); Shoalwater Bay, Broad Sound, *R. Brown 5449* (BM); sandhills on beach, growing thickly, Yeppoon, *Court s.n.* (BRI); Keppel Bay, *R. Brown 5449* (BM, K); Rockhampton, Fitzroy River, *Dallachy s.n.* (U); in remnants of light rain forest along Archer Creek, near Rockhampton, *White 12216* (BRI); rare, sides of sandstone ranges, Gracemere, *O'Shanesy 1824* (MEL); Crocodile Creek, Capricorn, *Bowman 96* (MEL); Curtis Island, *Mueller s.n.* (NSW); Gladstone, *Hedley 13* (BRI); Bustard Bay, *J. B. [Banks & Solander] s.n.* (BM); common on sandhills near beach, Rosedale, *Dovey 140, 153, 1010* (BRI). WITHOUT LOCALITY: New Holland, *Banks & Solander s.n.* (MO); East Coast, *R. Brown s.n.* (BM, K, MO); east coast of Queensland, *Mueller s.n.* (NSW). CULTIVATED: *ex hort.* *Kew s.n.* (BM).

Flowers which may be female have capitate and 2-lobed stigmas, ovaries about 2 mm. broad, and stamens about 4 mm. long with anthers only 0.5 mm. long and 0.3 mm. broad. Flowers which may be male have weakly capitate to truncate stigmas, ovaries about 1 mm. broad, and stamens about 6 mm. long with anthers about 2 mm. long and 0.5 - 0.6 mm. broad. Intermediate forms occur with weakly capitate stigmas, and stamens 4 - 6 mm. long.

Vernacular name: Rust-leaved Pittosporum.

31. *PITTIOSPORUM DALLII* Cheesem. Man. N.Z. Fl. p. 1134. 1906. (T.: *Dall s.n.*!).

Small trees 4 - 6 m. tall; branchlets gray, the young parts brown and puberulent. Leaves alternate, lanceolate-elliptic to oblong-elliptic, rarely obovate, obtuse, acute or acuminate at apex, acute to attenuate at base, coarsely serrate to entire, 5 - 10 cm. long, 2 - 4 cm. broad, dark green above, paler beneath, glabrous, coriaceous, the margins thin, flat, and ciliolate when young, thickened, slightly revolute and glabrate when mature, costa raised above and beneath, the secondary veins 14 - 18 per side, anastomosing, distinct above and beneath; petioles sparsely puberulent when young, glabrate, 3 - 18 mm. long, 1 - 3 mm. broad. Flowers terminal, about 40, in condensed umbelliform cymes; peduncles subtended by an approximate whorl of leaves and by caducous glabrous ciliate bud scales 15 - 21 mm. long; peduncles and pedicels 4-angular, up to 2 cm. long, accrescent in fruit, white-tomentose, each peduncle bearing 1 to many pedicels subtended by caducous, glabrous, linear bracts up to 1 cm. long. Sepals not imbricate, linear, 5 - 6 mm. long, about 0.5 - 1 mm. broad, glabrous; petals obovate, obtuse, 8 - 9 mm. long, 3.0 - 3.5 mm. broad, free, spreading from the base, white with red veins; stamens 7 - 8 mm. long, anthers elliptic-oblong, reflexed, 2 - 3 mm. long, up to 1 mm. broad. Pistil at anthesis longer than the stamens; ovary glabrous, about 3 mm. long, 1 mm. broad; style about 2 mm. long; stigma truncate. Capsules ellipsoid, 2-valved, about 15 mm. long, 9 mm. broad, green to black, glabrate; valves convex in transverse section, less than 1 mm. thick, coriaceous, with a slightly thickened placenta bearing alternate flattened and peg-like funicles, up to 2 mm. long, from the base to near the apex, dividing longitudinally into a woody mesocarp, which is shed on dehiscence, and a persistent membranous endocarp covering a cone-shaped mass of viscid seeds; seeds about 25, dark red, somewhat trigonal.

NEW ZEALAND: NELSON: mountains, near Collingwood, *Dall s.n.* (AK); same locality, 3500', *Gibbs s.n.* (A, AK, BM), 1854 (K).

Eleven trees have been found at Specimen Creek and Snow's Valley, near Boulder Lake, northwest Nelson. Others are reputed to occur in the vicinity, but as the locality is isolated and difficult to visit, the size of the population is not known. I suspect from their appearance that the flowers of the material available are male and that female flowers have not been collected.

Cheeseman¹⁷⁶ described the foliage as sharply and coarsely serrate from the flowering and fruiting specimens available to him (*Dall s.n.*, *Gibbs s.n.*). At Duncan & Davis Nursery, New Plymouth, cultivated plants have serrate leaves on the lowermost branches and as the lower cataphylls on new shoots. At the crown of the trees and at the apex of new shoots the leaves are entire. The species is cultivated as a rarity in New Zealand and England.

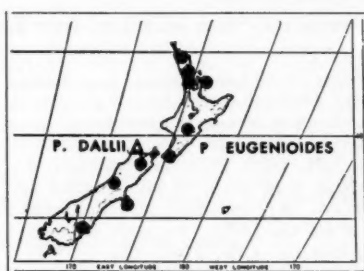


Fig. 36. *P. dallii* and *P. eugenoides*.

32. *PITTOSPORUM EUGENIoides* A. Cunn. in Ann. Nat. Hist. 4: 106. 1839. (T.: R. Cunningham s.n and 614!).

Pittosporum microcarpum Putterl. Syn. Pittosp. p. 15. 1839, ex char. (T.: A. Cunningham s.n.).

Pittosporum enkianthoides R. Cunn. & Hueg. in Putterl. loc. cit. p. 7. 1839, nom. nud. in synon.

Pittosporum umbellatum A. Cunn. in Putterl. loc. cit. 1839, nom. nud. in synon.

Pittosporum elegans Raoul, in Ann. Sci. Nat. III, 2:121. 1844. (T.: Raoul s.n.!).

Trees 6 - 13 m. tall; branchlets brown, glabrous. Leaves alternate, frequently crowded at the tips of the branchlets, oblong-elliptic to elliptic, subacute to acute at apex and base, entire, occasionally notched at base in juveniles, 5 - 15 cm. long, 2 - 4 cm. broad, glabrous, light green above, paler beneath, subcoriaceous, margins often undulate, the costa raised, the secondary veins 20 - 30 per side, anastomosing, obscure above, distinct beneath; petioles 0.8 - 1.8 cm. long, 1 - 2 mm. broad, glabrous. Flowers terminal or sometimes becoming lateral on development of a leading shoot from an axillary bud, 30 - 70, in spreading umbelliform cymes; peduncles subtended by an approximate whorl of leaves and by caducous, glabrous bud scales 1.0 - 1.7 cm. long; peduncles bearing branches which are again divided to bear 1 - 8 pedicels, branches and pedicels subtended

¹⁷⁶ Man. N.Z. Fl. ed.2. p.496. 1925.

by caducous, glabrous, linear bracts about 1.5 mm. long; peduncles, branches, and pedicels sparsely tomentose, accrescent in fruit. Sepals not imbricate, lanceolate, 1.5 - 3.0 mm. long, 0.5 - 1.0 mm. broad, glabrous; petals oblong, subacute to obtuse, 5 - 7 mm. long, 1.5 - 2.0 mm. broad, free, spreading from the base, yellow; stamens 3.0 - 5.5 mm. long; anthers sagittiform to elliptic-obovate, 1 - 2 mm. long, up to 1 mm. broad. Pistil at anthesis slightly shorter or longer than the stamens; ovary 1.5 - 3.0 mm. long, 1 - 2 mm. broad, tomentulose; style 1 - 3 mm. long; stigma capitate and obscurely 2-lobed or truncate. Capsules ellipsoid, 2-, rarely 3-, valved, acuminate, 9 - 10 mm. long, 5 - 6 mm. broad, green to black, glabrate; valves convex in transverse section, less than 1 mm. thick, coriaceous, with a slightly thickened placenta bearing near the middle 2 - 4 flattened and peg-like funicles up to 1 mm. long, dividing longitudinally into a coriaceous mesocarp, which is shed on dehiscence, and a membranous endocarp covering the seeds; seeds 1 - 8, reddish-black to black, irregular.

Known from the North and South Islands of New Zealand. Flowers from August to November.

NEW ZEALAND: NORTH AUCKLAND: Oruru, near Kaitaia, *Matthews s.n.* (AK); Kaitaia, *Matthews s.n.* (AK, MO); Onawero Bay, Wangaroa, *R. Cunningham s.n.*, 614 (K, as *P. microcarpum* R. Cunn.); in coastal forest remnants on Parua Bay Road, near Whangarei, *Corse s.n.* (AK). AUCKLAND: Paparoa, Kaipara, *Kirk s.n.* (AK); Henderson, *Cheeseman s.n.* (AK, GH, US); Waitakere, *Matthews s.n.* (AK); same locality, *Mackie s.n.* (AK); Anawhata, coast north of Piha, *Mackie s.n.* (AK) subtropical rain forest, Titirangi, *Chapman s.n.* (A); in second growth *Agathis australis* (Kauri) forest, Huia, Manukau Harbour, *Wood s.n.* (AK). THAMES: Kennedy Bay, *Matthews s.n.* (AK, MO); Coromandel, *Cheeseman s.n.* (AK, BISH, GH, NSW); Table Mountain, *Adams s.n.* (AK); Kaueranga, *Adams s.n.* (AK). VOLCANIC PLATEAU: 750 m., in mixed forest, Ohakune, *MacDaniels p.599* (CU); Ruapehu, *Attwood s.n.* (AK); Ohakune River, *Crompton s.n.* (K). WELLINGTON: York Bay, *Meebold 18278* (BISH). NELSON: Waimea woods, *Monro 66* (K); Nelson, *L. Travers s.n.* (K); Dun Mountain, *Mellor s.n.* (AK, MO); Foxhill, *Kirk 296* (BM). CANTERBURY: presqu'île de Banks, *Raoul s.n.* (GH, P, US); Akaroa, *Raoul 83* (K); same locality, *Belligny s.n.* (GH); Banks Peninsula, *Kirk 296* (GH, US); Lyttelton Hills, *Meebold 4745* (BISH). WESTLAND: Cobden Flat, Grey City, *R. H. [Helms] s.n.* (BM, MO). OTAGO: Dunedin, *Hector s.n.* (K); near Dunedin, *Thomson s.n.* (AK); bush, Dunedin Belt, *Watt s.n.* (K); Mokopeka, *Meebold 5497* (BISH); in mixed forest, Hunter Hills, *Anderson 210* (A, F, K, MO, US). WITH-OUT LOCALITY: *A. Cunningham s.n.* (GH, U); *Bidwill s.n.* (K); *Brown 107* (BISH); *Colenso s.n.* (BM, K), 710, 768, 768b, 3789 (K); *Harvey s.n.* (GH); *Raoul s.n.* (A); *R.N.Z. Inst. Hort. s.n.* (NSW).

Flowers which are probably female have 2-lobed capitate stigmas slightly exserted, plump ovaries about 3 mm. long, 1.5 - 2.0 mm. broad, and sagittiform anthers which appear to be abortive. Flowers which are probably male have truncate stigmas slightly below the stamens, slender ovaries 1.5 - 2.0 mm. long, about 1 mm. broad, and elliptic obovoid anthers which appear to be functional. Godley has informed me (personal communication) that the species is dioecious.

I am indebted to Mr. W. T. Stearn of the British Museum of Natural History, London, for the following note on the priority of Cunningham's names over those of Putterlick.

That part of Allan Cunningham's paper "Florae Insularum Novae Zelandiae precursor" which deals with *Pittosporum* was published in *Annals of Natural History* Vol. 4, dated 1840, on the titlepage, whereas Aloys Putterlick's *Synopsis Pittosporarum* (Vienna) is dated 1839 and hence would appear to have priority. On this assumption J. do A. Franco in *Bol. Soc. Broter* ii. 25:227 (1951) has replaced the generally accepted name *Pittosporum eugenioides* A. Cunn. by *P. microcarpum* Putterl. This is not the only example of nomenclatural conflict between the two publications. Hence it has seemed desirable to investigate the matter further. Actually Cunningham's paper (pages 106-111) was published in *Ann. Nat. Hist.* no. 22, which is dated 'October 1839' both on its wrapper and on p. 74; a London publication, it was received by the Linnean Society of London on 2 October 1839, which can be confidently accepted as its date of issue. Putterlick's *Synopsis*, published at Vienna, was not received by the Linnean Society until 14 Jan. 1840; this suggests that it may have been issued towards the end of 1839. Unfortunately, the records of the Viennese publisher F. Beck were destroyed in the 1939-44 war, and no other Viennese source of information has been found. However, information about Austrian publications quickly became available in Leipzig, the well-organized centre of the German book trade. Thus the half-yearly catalogue of J. C. Hinrichs (*Verzeich. neuer Bucher Juni-Dec. 1837* p. 182) lists Putterlick's *Synopsis* as published between June and December 1839. More precise evidence is given by the weekly *Allgemeine Bibliographie für Deutschland* 1839 (48):719 (29 Nov. 1839) where it is listed as a new publication. Even allowing as much as six weeks for the announcement of its publication to be sent to Leipzig by Friederich Beck, Putterlick's work would still be antedated by Cunningham's. No evidence has been found, despite extensive search, to suggest that Putterlick's came out earlier. Hence it can be accepted as published at the same time, in which event Cunningham's names are to be retained, having been adopted by J. D. Hooker who was the first to unite the species of Cunningham and Putterlick (cf. *Int. Code Bot. Nom.* 1952, art. 67), or Cunningham's paper issued on 2 October 1839 can be accepted as having priority over Putterlick's *Synopsis*, taking November 1839 as the date of issue for this in accordance with the only definite evidence available. Both procedures confirm the established nomenclature.

The type sheet at Kew bears three labels:

1. "*Pomaderris microcarpa*, Wangaroa, N. Zeal'd. R. Cunningham."
2. "*Pittosporum microcarpum*. R.C. (non. Putt.). (*P. eugenioides* A.C. Mss.). I gave it the Baron with this name. fl. non. vid. at Onewero Bay, Wangaroa, New Zealand, R. Cunningham. 1833."
3. "Taken from Herb. A. Cunningham, No. 614. *P. umbellatum* Gaert. (Putt.). *Pittosporum eugenioides* A. Cunn. Fl. N. Z. 1 - 22. *Ann. Nat. Hist.* V. iv. p.106. New Zealand. R. Cunningham 1833." The sheet is cited as "*R. Cunningham s.n.* and 614" to identify it. Presumably "the Baron" is Baron von Huegel whose collectings of *Pittosporum* were described by Putterlick.

Pittosporum eugenioides is commonly cultivated as a hedge-plant and ornamental tree in the United States, southern England, France and New Zealand, and I have seen specimens from Portugal (Franco s.n. K). The plant distributed by C. F. Baker of California as *P. undulatum*, "one of the most valuable species of the genus for garden and hedge planting" (*Economic Plants of the World*. No. 119.) is *P. eugenioides*. (A, CU, MASS, MO, NSW). A form with variegated leaves has been available in the trade for many years as var. *variegata*. Cheeseman¹⁷⁷ recorded that the abundant fragrant flowers were formerly used by the

¹⁷⁷ *Man. N.Z. Fl.* ed.2. p.496. 1925.

Maoris who mixed them with fat and applied them to their bodies, and the essential oil present might be suitable for the perfume trade.

Vernacular names: *Mapau*, *Tarata*, Lemon Matipo, Lemonwood, Lemon Tree. *Tarata* is the name preferred by modern writers.

EXCLUDED OR DOUBTFUL SPECIES

Pittosporum callicarpum Dom. in Bibl. Bot. 22: 713. 1925. I have not seen a specimen of this species.

Pittosporum nanum Hook. in Comp. Bot. Mag. 1: 275. 1835 = *Mariantbus procumbens* (Hook.) Benth. Fl. Austr. 1: 117. 1863.

Pittosporum procumbens Hook. in Comp. Bot. Mag. 1: 275. 1835. = *Mariantbus procumbens* (Hook.) Benth. Fl. Austr. 1: 117. 1863.

Pittosporum parviflorum Putterl. in Lehm. Pl. Preiss. 1: 189. 1844-5. I have not seen a specimen of this species but the drawings preserved at Vienna and generously lent by the Director of the Naturhistorisches Museum do not represent a species of *Pittosporum*.

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THE CULTIVATED BEANS OF THE PREHISTORIC SOUTHWEST*

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Beans, corn, and squash were the basic cultivated plants of pre-Columbian North America. There is no monograph on prehistoric beans, and the history of their distribution and a description of their variations have not been published. Although prehistoric collections are few as compared with those of corn, a study of available material can contribute significantly to the history of agriculture in North America.

Apart from horticultural, agricultural, and other practices which create or modify ecological conditions so that domesticated plants and weeds might survive, man exercises conscious and unconscious varietal selection. Patterns of selection are set by culture-based criteria, and attitudes towards plants and selections are made within the limits of plants available and primary factors such as geography and climate.

The roles of plant geography, ecology, and of human culture in shaping the species composition and distribution of beans are taken up in the first part of this paper. The factors which determine the kinds of plant materials available for this sort of study are also discussed. Descriptions of the materials and their distributions in the Southwest are subsequently given, with discussions of the part they play in the history of cultivation and variation in beans.

Acknowledgments:—The author wishes to express his gratitude to the Chicago Natural History Museum and the Missouri Botanical Garden for the use of their research facilities, and to Dr. Hugh C. Cutler, Associate Director of the Missouri Botanical Garden, who proposed this study and contributed many useful suggestions. Travel in the Southwest was made possible by Dr. Cutler and the University of Chicago where the author was enrolled as a graduate student. Grants from the University of Chicago and the Chicago Natural History Museum aided field work in Mexico. This study could not have been completed without the cooperation of the institutions (listed in the explanation of Table VII) which made their collections available.

TAXONOMY AND DISTRIBUTION OF CULTIVATED BEANS

For purposes of this study beans are defined as the seeds of cultivated plants belonging to the genus *Phaseolus*. Bentham (1841) placed this genus with other trifoliolate genera in the papilionaceous tribe, PHASEOLINAE, sub-tribe EUPHASEOLEAE, but separated it from other genera of the sub-tribe by the coiled keel characteristic of *Phaseolus* flowers.

* An investigation carried out at the University of Chicago, Chicago Natural History Museum, and the Missouri Botanical Garden, and submitted as a thesis in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Department of Botany, University of Chicago.

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The genus *Phaseolus* contains approximately 180 species (Ditmer *et al.*, 1937) distributed throughout the tropics and warm temperate regions of the World (Bailey, 1949). Distinctions between the Old and New World cultivated species are several, indicating long separation and independent evolution as cultigens (See Table I).

TABLE I
DISTINCTIONS BETWEEN OLD AND NEW WORLD CULTIVATED BEANS

	Old World	New World	Authority
Flower color	Usually yellow	Red, rose, violet, white (may be yellow-tinged)	Bailey, 1949, Piper, 1926
Seed size	Small	Large (teparies small)	
Testa pattern	Little variation	Highly varied	
Pods	Narrow	Broad	Hedrick, 1931
Flower morphology	Left keel petal with horn-like process	Left keel petal without horn-like process	Piper, 1926
Growth habit	Annual	Annual or perennial	Piper, 1926
Pathology			
<i>Cercospora cruenta</i>	Susceptible	Resistant	Piper, 1926
<i>Gloeosporium lindemuthianum</i>	Resistant	Susceptible	

Another distinguishing character which might be added is the geographical distribution of species included in the genus. According to Ditmer (Ditmer *et al.*, 1937) 126 species of *Phaseolus* occur in the Americas; 54 are natives of South Asia and East Africa; only two species are indigenous to Australia, and but one assigned to Europe.

As a result of the facile development of cool-temperature ecotypes and their acceptability as food, the range of the cultivated beans of the New World has been extended to the regions of Asia and Europe for which the Asiatic species have proven too thermophilic (Ditmer *et al.*, 1937). Photoperiodic adaptability (Allard and Zaumeyer, 1944) has apparently also contributed to the wide latitudes available to cultivation of the New World types. The Asiatic species, on the other hand, have not proved as successful for dry edible beans in the Americas as the highly productive and familiar common and lima beans. The mung bean, *Phaseolus aureus*, used in the sprouted form in oriental cookery, is the only Old World bean to have been grown in quantity in the United States. These beans were cultivated in Oklahoma to supply domestic needs for sprouting beans during the 1940's when Asiatic supplies were cut off.

Phaseolus vulgaris, the common garden bean, or kidney bean of Anglo-America, is frequently confused with the "cow pea" or "black-eyed bean," *Vigna sinensis* of Asiatic origin, which also provides green immature pods and dry seeds used for human food. The snap beans, both green and wax-podded, and field beans also

may usually be referred to *P. vulgaris*. In Mexico they are known as the *frijol*, in Colombia as the *frisol*, the names of Spanish origin having largely replaced the indigenous terms in these countries and elsewhere in Latin America. The numerous Spanish or English horticultural varieties are usually multinominal and are based upon seed characters such as color, color pattern, shape, supposed derivation of original seed (as Mexican Red, Hidatsa Red), use (as Navy Bean), productivity, growth habit, precocity, and the like.

CENTERS OF DOMESTICATION OF AMERICAN BEANS

The cultivated beans which were domesticated in the New World are represented by four species. A brief history of their origins is given below.

Phaseolus vulgaris L. (Sp. Pl. 723. 1753), Kidney or Common Bean: This highly variable species was considered by Linnaeus to be Asiatic in origin. De Candolle (1886) was convinced that the common beans are native to the New World but, because he was uncertain of the validity of archaeological evidence, placed them among plants of doubtful origin. The use of archaeological material in the demonstration of the New World origin of common beans is indicated below. Ivanov, according to Bukasov (1930), assigned the common beans to the Mexican-Guatemalan highlands region on the basis of varietal diversity.

McBryde (1945) and Burkart (1943) reported *Phaseolus* species which they considered were non-domesticated forms of the cultivated common bean. Collections of similar kinds from the Mexican plateau and Guatemala also exist, the descriptions of which have not as yet been published. The only such material which has been investigated experimentally is that of Burkart and Brücher (1953). They found beans from Honduras and Argentina to be sexually compatible with cultivated varieties of *P. vulgaris*, but not with those of *P. coccineus* or *P. lunatus*. The floral characters were similar to those of *P. vulgaris*. The Argentinian collections were from uninhabited (at the present time) high mountain valleys and were not thought to be escaped forms. The chromosome number in root tips of both the Central and South American material was 22, as in other members of the tribe. Burkart proposed the following nomenclature for *Phaseolus vulgaris* as now understood:

P. vulgaris L. *sensu amplissimo*

P. vulgaris subsp. *aborigineus* Burkart

P. vulgaris subsp. *cultigenus* Burkart (all cultivated varieties)

It would seem likely that a number of the so-called "wild *P. vulgaris*" types might have had an influence on what are known as the cultivated common beans by way of hybridization.

There is little doubt that the common beans were domesticated in the New World from a form or forms not yet specifically known, and it is probable that the highlands of Mexico and Central America which show the greatest diversity of cultivated forms (Ditmer *et al.*, 1937) were the center from which domesti-

cated varieties spread first throughout agricultural Indian-America, and later to the other continents.

Phaseolus lunatus L. (Sp. Pl. 724. 1753), Lima Bean:—Ames (1939) cited Bentham as having referred the origin of the lima bean to Brazil but stated that it is not known there in the wild state. Mackie (1943) concluded that Guatemala, as the center of varietal diversity and the region from which a wild bean (considered by him to be *P. lunatus*) has been collected, is the place in which lima beans were first domesticated.

Phaseolus coccineus L. (Sp. Pl. 724. 1753), Runner Bean or Scarlet Runner Bean:—Runner beans are not definitely known from any reliably dated archaeological site of pre-Hispanic America. The scarlet runners which have been found in the Southwest are cultivated on a small scale by the Hopi or have been found in caves and reported as viable. Whiting (1950) made reference to the oral traditions concerning these supposedly ancient beans; when planted, they were supposed to have sprouted and produced crops of the edible dry seeds. The author has heard from individuals in the Southwest that progeny of seeds taken from old cave habitations are of the large white type (R 1, Tables IV and V) and are said, when cooked, "to taste like mashed potatoes." It is more than probable that the limits of duration of viability would preclude any considerable age being assigned to these collections.

The reports of Ivanov (Bukasov, 1930) and of Ditmer (1937) of distribution of *P. coccineus* limited to southern Mexico and Guatemala, and other reports (cited below) of the occurrence of *P. coccineus* as a weed in fields of cultivated common beans in the same region indicate that this region is a center of domestication for this species.

Phaseolus acutifolius A. Gray (Pl. Wright. 1:43. 1852), Tepary Bean:—The cultivated forms of this species, described as *P. acutifolius* var. *latifolius* (Freeman, 1912), are known mainly from two centers: one is that of the Indian populations of southern Arizona (Freeman, *op. cit.*); the other, found by Russian botanists, is the Pacific Coast of Chiapas in southern Mexico (Bukasov, *op. cit.*). Although Freeman proposed the Sonoran Desert region as the probable center of domestication of the tepary bean, Bukasov stated only that Mexico is the center of origin. The question of origin of the tepary bean will be discussed again in this paper.

The greatest diversity among the cultivated beans was found by Russian investigators (Bukasov, *op. cit.*, p. 510) in southern Mexico and Guatemala. They thought that the highlands of these regions saw the earliest domestication among the Maya, with subsequent adoption by lowland peoples, along with corn and other cultigens. Bukasov, according to Ditmer (1937), maintained that contact between Mexico and Peru did not come until a relatively late date and that on the arid coast of Peru a second center of origin for large-seeded, cultivated *P. vulgaris* was established. Prehistoric common beans of the Ica valley (Table VII, collec-

tion numbers 225-231) are larger than those found in archaeological sites of other, non-Peruvian cultures; but so are the lima beans, and Cuzco maize (collections of Hugh C. Cutler) is larger-kerneled than any other race. It would seem at least possible that ancient Peruvians had a predilection for large-seeded crops and, through selection, developed large-seededness to the extent of the genetic potentiality of each variety.

Wild species of *Phaseolus* are abundant throughout the warmer regions of the Americas, especially North America (Piper, 1926). Coincident with this distribution may be found not only the greatest number of forms of the common bean, but also the ranges of species which have likely had influence in building the polymorphic character of *P. vulgaris*.

Bukasov (1930) and others reported the common occurrence of *Phaseolus coccineus* as a tolerated, useful weed in plantings of the common bean in Chiapas—a situation which may be expected to persist in Guatemala. This species, although observed by the author while in Mexico in 1954 in abundance in the markets of towns situated at higher elevations in Chiapas, is not seen in the lowland *tierra caliente*. The "tropical black complex," indicated by Freytag (unpublished thesis) to be the source of variability of the common bean in Central America, certainly extends its influence at least into the tropical lowlands of Mexico. In other regions of ancient bean cultivation, such as the arid Southwest, other hybridizing species probably have had little influence on the common bean because of the low rate of outbreeding in *P. vulgaris* under arid conditions.

For a review of the systematics and synonymy of the cultivated beans, as well as their recorded history and appearance in the herbals, the reader is referred to Van Eseltine's discussion in "The Vegetables of New York" (Hedrick, 1931, pp. 3-16) and to Burkart's (1943) diagrams of seed types of all cultivated bean species.

GEOGRAPHICAL LIMITS OF THE SOUTHWEST

Although of importance to the present problem, the precise geographical and ethnic limits of the Southwest region are not easily determined. The question of how to define the Southwest, whether in terms of distribution of subsistence patterns, geography, ecology, or other criteria remains a matter for open discussion among anthropologists and other specialists. This is evidenced by Kirchhoff's recent paper (1954) and the comments of Kroeber, Beals, and Sauer. Kirchhoff considers the "... Greater Southwest areally to include Central, Southern and Baja California, the Great Basin, Arizona, New Mexico, Southern Coastal Texas and Northern Mexico south to the Sinaloa and Panuco rivers." Ecologically and culturally he distinguishes arid America with a gathering population from coexisting Oasis America and farming peoples.

The difficulties in presenting a definitive boundary scheme for this region are discussed by C. Sauer following Kirchhoff's article. He reviews the vast areas of the Greater Southwest for which the archaeological record remains virtually unexamined and for which there is still little information on migrations of peoples,

diffusions of agricultural techniques and crops, and cultural data, including descriptive and analytic linguistic materials. He suggests that Kirchhoff's classification is essentially an ecological one, based upon geographic considerations, and that only more information will enable classification in cultural terms and reveal the relationships underlying the culture history of the region.

For purposes of this paper, the Southwest region includes the present states of Arizona and New Mexico, and parts of Utah, Colorado, Texas, Nevada, California, and northern Mexico.

SOUTHWESTERN CULTURE HISTORY AND ENVIRONMENT

Geology and archaeology give evidence of the presence of non-sedentary human cultures in the Southwest at least 15,000 years ago. Some time before 300 B. C. differentiations appear in the archaeological record which show that these hunting and gathering peoples had begun to develop along somewhat divergent cultural lines.

In southern Arizona, the most arid portion of the Southwest, the prehistoric cultural development has been termed the "Hohokam." It is not clear at what time agriculture became established in this region, nor is it known whether it was preceded or followed by pottery. However, agriculture was well established by 300 B. C., and irrigation reached a high development among the Hohokam. The contemporary Pima and Papago tribes live in the area once inhabited by the Hohokam.

Peoples living to the east and northeast of the Hohokam, in what is now New Mexico, have been called the "Mogollon," and their region included the best-watered and most mountainous sections of the Southwest. Corn and squash cultivation was established among the Mogollon as early as 2,000 B. C., and pottery did not appear until considerably later. The Indians now occupying the Mogollon area are of the Apache group.

In northern Arizona and the Four-Corners region of Arizona, Colorado, New Mexico, and Utah emerged the "Anasazi" culture. The Anasazi of pre-pottery times have been called the "Basketmakers," and their successors, who made fired pottery, have had their culture history divided into four "Pueblo" periods. Pottery came to the Anasazi later than to the other groups; corn and squash agriculture were pre-ceramic among the Basketmakers and appear not to have been derived directly from the Mogollon or Hohokam. The Hopi, the Zuni, and Rio Grande Pueblos continue the Anasazi Pueblo tradition. The Navajo, who, like the related Apaches, were late arrivals to the Southwest, also occupy much of the Anasazi area.

Entering the Pueblo Southwest in the 16th century, the Spaniards found a few concentrations of farming peoples inhabiting a large area which formerly supported a more disperse population. These concentrations probably began with the droughts of the 13th century and the destruction of agricultural land as a result of arroyo cutting when more reliable water sources, such as those of the seeps and springs of the Hopi mesas, were sought. Religious and political domination by the Spaniards

brought about rebellions and migrations of refugees which augmented the normal contact among native peoples and certainly led to the introduction and exchange of crop varieties.

Contemporary Southwest Indian peoples, who are to varying degrees the heirs and continuers of the cultures of pre-Hispanic and pre-Anglo-American times, continue the cultivation of many ancient crops in addition to relatively recent ones.

Use and Preparation of Beans:—It has been pointed out that, with the possible exception of the tepary, the centers of origin of American beans must be sought outside the area of prehistoric occupation with which this paper is concerned. It follows that beans entered this region as cultigens by diffusion and with the plants came modes of use and cultivation.

Carter has observed (1945) that boiling of dry beans without preliminary soaking is the common practice among native southwestern peoples in modern times. This practice has been similarly observed in many parts of Mexico by the author and is probably a very early form of preparation. Laborious preparation of foods is common in modern non-industrialized societies; witness the stone-grinding of corn in tortilla-making and the grating and leaching of mandioca. But these are basic starch crops. Were beans important or favored enough to warrant the protracted stone-boiling in woven baskets and high fuel consumption necessary in pre-pottery times?

Carter (1945, p. 75) thought it likely that, if bean culture did begin in pre-pottery times, the use was probably as a green vegetable. It is worth while here to consider the possible uses of beans by prehistoric Indian groups.

The green pods of common beans have been used among native peoples of Indian America; in Mexico they are called *ejote*, a word of Nahuatl origin (Santa-maria, 1942). Pod beans as used by ancient Americans, however, were certainly not like the string or snap bean of today. The earliest string beans of low fiber to be cultivated were reintroductions to America of European selections in the 19th century (Hedrick, 1931). No stringless bean is known to have been contributed by Indian agriculture.

The use of the immature fruits of the common bean is described by Waugh (1906) for the Iroquois of Canada, in which the boiled pods were chewed and the fibrous remains ejected. That this pattern of consumption, or one like it, might have been expected among the southwestern peoples is evident from the finds of masticated vegetable fiber masses in many archaeological sites of the region. Most of these so-called quids have been described as agave or mescal quids, but for the most part they have been reported by persons unfamiliar with the identification of fragmentary plant remains. However, remains of this type have been examined by Cutler (Martin *et al.*, 1952) for Tularosa Cave and by Kaplan (unpublished) for Cordova Cave, two Mogollon sites with pre-pottery remains, and in Tularosa Cave, with beans associated with the pre-pottery remains. Only one of the hundreds of fibrous wads proved to have been a bean pod. There is no reason

to believe that masticated indigestible fibers from bean pods would not have been expectorated on the cave floor as were the wads of agave, yucca, cactus stems, and certain unidentified fruits, probably asclepiads. The conclusion that bean pods in the early levels of these sites were not extensively used is inescapable. The possibility of removal of the "strings" before cooking, however, cannot be excluded. Shelling and cooking of immature seeds would not be more difficult than the preparation of the immature pods in a pre-pottery technology.

That peoples of Indian America relied upon beans rather than animal foods as a source of protein is well known. Linton (1940) discussed the role of a balanced diet in culture history and pointed out that in Indian America starch and protein crops (beans) have been used, in contrast to other parts of the world where starch crops and animal food, or other kinds of legumes, have provided the balance. D. B. Jones *et al.* (1938) indicated the complementary nature of bean and corn amino acids in providing dietary protein needs.

The adequacy of beans as a protein source depends ultimately upon their utilization and preparation. The protein value of immature beans as given by Chatfield and Adams (1940) is highest for (almost mature) green-shell lima beans, 7.5 per cent of the total weight, while in green snap beans there is less than 3 per cent protein. For several commercial North American mature dry-shell varieties tested, protein was 22 per cent of the total. In addition, the green products are quite low in fuel value while the mature seeds are high. When mature and dried, beans are at the most useful stage, for then they can be employed by an otherwise protein-poor economy and also can be relatively easily stored.

Soils.—Tolerance of a wide variety of soils, if they are well-drained, is characteristic of cultivated American beans in general. The species differ, however, in response to alkali, acid, and saline soils, and these different responses have probably influenced the distribution of beans in the Southwest. Acid soils are not encountered in the arable Southwestern lands, while alkaline soils are more common in poorly drained alluvial lands of the southern and southwestern parts of the region (U. S. Dept. Agr. Yearbook, 1938, p. 110). The irrigation practices of the ancient Hohokam may well have contributed to alkalinity in these soils. Hendry (1918) indicated the low tolerance of commercial *P. vulgaris* varieties to alkalinity and considered *P. acutifolius* varieties as moderately tolerant.

Saline soils (.02 per cent NaCl) affect bean growth (Wadleigh *et al.*, 1943) by increasing the severity of drought conditions. The superior drought resistance of tepary beans is well known, while common beans are severely affected by a relatively few days of wilting. The small-seeded limas or sieva beans are characteristically more resistant to aridity and high-temperatures than are the large-seeded limas (Mackie, 1943). That salinity has been a factor in Indian agriculture, at least in the area of the Hohokam, is attested to by the Pima practice of tasting the soil preparatory to planting (Heintzelman in Emory, 1859, p. 112). If salt were detected, the soil was considered unfit for agriculture. It is probable that salinity

below the threshold of detection by human taste is sufficient to influence plant growth by altering water relations under drought. Many of the sites selected as acceptable could have been salty enough to intensify the effect of arid conditions.

Irrigation.—Emory (1859), in his survey of the Mexican-U. S. boundary, noted that little agriculture could be engaged in without water supplied in addition to the seasonal precipitation. To meet the water requirements the Pima and Papago (Castetter and Bell, 1942) have employed irrigation systems, drawing water from the Gila River as did the earlier Hohokam peoples. Halseth (1936), by aerial survey, found about 125 miles of ancient irrigation canals in the Salt River Valley and other canals about half that extent in the Gila Valley. Some of the canals are more than ten miles long, and all ruins associated with them were Hohokam in culture. The very high temperatures and high evaporation rates characteristic of southern Arizona may be supposed to have encouraged the cultivation of teparies rather than other beans despite irrigation and flood-water farming.

Extensive irrigation by canals has not been shown to be characteristic of farming among the Basketmaker and Pueblo peoples to the north, and the author is unaware of any irrigation in use in prehistoric Mogollon cultures. Some irrigation is practiced by the Hopi of Moencopi according to Whiting (1950, p. 10), who implies that this was learned from the Mormons. The terraced gardens observed by the author at the Hopi village of Hotevilla were irrigated by hand, and Whiting indicates that this is the general practice among the Hopi. According to him, neither corn nor bush-type beans planted in the same or separate fields in sandy washes and alluvial soils by the Hopi and the Navajo are irrigated except by occasional flood water.

Effect of Daylength.—Carter (1945) has stated that the majority of native Southwest beans are bush types, and the observations of Whiting (1950) and others that field-grown beans are planted apart from corn would substantiate this. Allard and Zaumeyer (1944) have studied the photoperiodic responses of many strains of cultivated species of *Phaseolus* and found that the bush types of *P. vulgaris* are mostly day-neutral in their flowering and vegetative responses. Daylengths used in their study were comparable in range to those of the latitudes of the Southwest. The semi-determinate or semi-pole types studied by them exhibited more positive reactions to photoperiod than the bush types. The twining habit of the semi-pole varieties was emphasized by long days and accompanied by a delay in flowering, while shorter-day treatment was correlated with earliness and the determinate habit. Thus varieties which were determinate at lower latitudes might well have taken on vining characters when introduced to the Southwest. It is apparently precisely this factor which prevents the semi-pole California Pink and Pinto varieties from entering the northern part of the western range where the delay in flowering would mean injury because of early frosts.

While many of the pole types were shown by Allard and Zaumeyer (1944) to be short-day, they proved to be mostly day-neutral for flowering. This type

remained twining at all daylengths so that the varieties would be expected to be twining even under conditions of short days when the semi-pole would be determinate. The lima beans tested were all day-neutral while runner beans were long-day. Allard and Zaumeyer did not include tepary beans in their work.

Planting dates to take advantage of the limited precipitation and of flood waters, or to avoid frost periods, might have been adjusted without difficulties arising from new photoperiodic relations. The diffusion of some bean varieties within the Southwest may have been impeded by photoperiodic reactions, but there is strong evidence from experimental and field studies that this environmental factor does not restrict bean distribution within this area.

Vegetal Remains of the Prehistoric Southwest.—Much of the Southwest region is arid, and many of the ancient peoples lived in caves, shelters, or houses which have remained relatively dry. For this reason perishable materials have been better preserved than in more humid areas such as in the Mississippi Valley and other parts of the eastern United States. Even in less-protected Southwestern ruins fires often occurred at or soon after the time of abandonment, frequently charring and preserving vegetal materials.

Collections of prehistoric vegetal materials have been studied and reported upon by various authors. Some of these studies have only provided descriptions of the materials found at particular sites; others have related their descriptions to other collections and other aspects of Southwestern culture. Among the latter, Carter's (1945) studies have been most comprehensive for remains of cultivated plants. He theorized that the division between Hohokam and Anasazi corn and a change in corn types is a result of Mexican and later Eastern (United States) influences. Some question exists as to the extent of the Eastern influences in the corn of the prehistoric Southwest. The steady reduction of the percentage of maize cobs with high row-numbers reported by Cutler (Martin *et al.*, 1952) for the more recent periods (especially 200–400 A. D.) of Tularosa Cave appears to be a pattern for the entire Southwest. Nickerson has recently (1954) provided evidence on the basis of anatomical characters to show the similarity of maize from widely distributed Southwestern sites.

Beans recovered from archaeological sites have received the attention of botanists and students of human culture. Earlier studies were directed toward demonstrating their place of origin by their presence in undisputed pre-Columbian ruins. Jones (1952) has adequately discussed the historical phase of prehistoric beans. He has shown that a mixed collection of charred seeds, later described as both *Phaseolus vulgaris* and *P. acutifolius*, found in Canyon de los Muertos, Arizona, was used by Ludwig Wittmack in 1888 to demonstrate conclusively the American origin of the garden or common bean, *P. vulgaris*. More recently beans dating from prehistoric times have been described from sites in the Southwestern United States in relation to migrations and diffusion of culture traits and other aspects of culture history. Most of this discussion has been of a highly general nature, and little attempt to classify bean types on a subspecific level has been made.

It is hypothesized that the distribution of beans in the prehistoric Southwest will show a relationship to the cultural subdivisions which have been recognized by archaeological studies. The distribution patterns can be expected to reveal something of the antiquity and history of beans as cultivated plants in this region.

MATERIALS AND METHODS

SOURCES AND COLLECTION OF MATERIALS

The data presented in this paper were collected from materials studied at or obtained on loan from museums and universities where they had been deposited by archaeologists and ethnologists active in the field of Southwestern prehistory. A trip¹ to the Southwest during the summer of 1953 enabled the author to study materials in museums of that region; the institutions visited are given in Table VII. In the course of this field work, observations were made of Hopi and Navajo cultivated lands. Further observations during field work² in rural Mexico in 1953 and 1954 contributed to the author's understanding of comparative native American farming and food habits.

Modern archaeological excavations are carried out with careful regard for the position of artifacts recovered and their relation to dates of occupation and culture change. Vegetal materials obtained from excavations are to a greater or lesser degree artifacts and can sometimes be dated reliably with respect to their associations with other material for which dates have been established. Cutler (Martin *et al.*, 1952) has pointed out the value of large samples of plant materials, such as corn cobs, in describing a specific class of vegetal remains occurring in a particular time level of a prehistoric site. One advantage of a large sample is that it minimizes the influence of extraneous material which may have been brought in from other levels by rodents or by human disturbance such as burials in the fill. Beans, unlike corn, seldom have a waste or by-product which can accumulate in the debris of a cave or dwelling over a period of years. Threshing of dry beans, as has been described in historic times among Indians in the Southwest (Whiting, 1950; Castetter and Bell, 1942), is carried out in flat cleared areas well removed from habitation. The bean seeds arrive at the habitation ready for the pot or storage with nothing to be discarded except, perhaps, the culls. The practice of threshing beans in the field from the dry picked pods or from piles of the harvested whole plants is widespread in Indian America. It is reported from coastal Peru (Gillin, 1945) as well as from the southwestern United States, and for representative climatic regions of Mexico (Brand and Nunez, 1951; Foster, 1946; Kelly and Palerm, 1950), where it was observed by the author in 1954. A clue as to why pods are occasionally encountered in some abundance in prehistoric occupied sites is pro-

¹ Supported in part by a Wychwood Fellowship in the Department of Botany, University of Chicago.

² Supported in part by a Chicago Natural History Museum Fellowship in the Department of Botany, University of Chicago.

vided by Kelly and Palerm (1950) referring to the hand shelling of beans during rainy weather when the pods cannot be rendered fragile by drying. Also, small amounts of beans may be brought in and shelled by hand for daily use before the main harvest or threshing. These practices, if carried on in the shelter of the dwelling, could account for the large numbers of pods described by V. H. Jones (Steen and Jones, 1941) and materials recently excavated from caves in Tamaulipas, Mexico, by R. S. MacNeish.

The uncharred bean seeds, fortunately for the archaeologist and botanist, have escaped being eaten or have been left after being used in connection with burials or ceremonial practices. The beans of Tularosa Cave, for example, were dispersed throughout the debris and were probably seeds which had been dropped accidentally. Some of these seeds may have been moved from their original positions by rodent or human activity, as mentioned above, but the collection as a whole can be said to characterize the period of occupancy of the site. Notwithstanding the fact that there are sites (see Table VII) where time sequence of bean collections has been fixed with some certainty, the emphasis in this paper is on the larger time and cultural units and their relation to the regional history of agriculture. Thus the individual collections which we have before us obtain greater significance as they are considered with related collections in the Southwest. Dates or cultural affiliation for each collection are taken from published or otherwise indicated data based on standard methods and nomenclature used in Southwestern archaeology.

Samples obtained have been generally small, or at least of smaller numbers than desirable. Samples always suffer in some degree from subjectivity in treatment. The vegetal materials were collected by persons who, through lack of specialized training in the recognition of plant materials and working under trying field conditions, often may have failed to recognize and obtain all the material available. Of the various classes of prehistoric cultivated plant materials, corn cobs, because of their size and durability, are most easily recognized, while squash and bean seeds are less noticeable. This is particularly true with scattered charred materials: squash seeds become frustratingly fragile, and beans, losing their seed coats, occur as elusive, single cotyledons. Beans are most readily collected when observed in conjunction with larger artifacts, such as ceramic vessels or fragments of more immediate interest to the archaeologist or his hired diggers. Laborious screening of the fine debris which usually fills long-abandoned ruins is the most effective technique for the recovery of seeds. Flotation also is useful in the separation of charred materials from less buoyant debris.

CLASSIFICATION OF MATERIALS

As each collection was received it was first examined for state of preservation; that is, was it desiccated and in good condition, partially decayed, charred? Then all bean material was separated from contaminants. The state of preservation determined the number of characters which could be used for diagnosis, and accordingly a classification was made using as many as possible of the characters

discussed below. The divisions were made first on the basis of species and then into types of the species. The latter were the smallest divisions, and each putative type was treated as a population which was described in its entirety or from a random sample of its best-preserved units.

The term "type" is used here in a sense which is coordinate with "variety" as used in such publications on bean classification as "Garden Beans" (Irish, 1901), "American Varieties of Garden Beans" (Tracy, 1907) or "The Vegetables of New York: Beans" (Hedrick, 1931). "Variety" in these works, although not specifically defined, is taken to mean sexually propagated generations of plants which retain characteristics enabling the separation of one such continuum from another of the same species. Thus the characteristics used would be subspecific and, in a cultivated plant, are those which affect its usefulness or recognition. An example of the first kind of character might be precocity or disease resistance, and of the second, seed-coat pattern. Since only a relatively few of the cultivated beans are recorded to have been developed under recent cultivation, the term "horticultural variety" is not much used. In agricultural practice bean-seed characters, along with agronomic characteristics, are much used in classifying the varieties. The nature of the present study precludes the use of agronomic characteristics; seed characteristics are relied upon. This makes it uncertain, at best, to include the materials treated here with the named varieties used in the above-mentioned works or as listed in seed catalogues. For this reason the series of types described for Southwestern beans cannot have formal taxonomic standing but are presented as entities with which new materials may be compared.

Cardenas (unpublished thesis), Freytag (unpublished thesis), and others have presented certain correlations between seed and vegetative characters, but these are largely of a general nature not always useful in determining the nature of the parent plant if only the seed is available. Pending further studies which will enable more certainty in correlations of this sort, one can state similarities between the seed types and the named varieties.

Diagnostic Characters.—Because of their large size and frequently distinctive colors and markings, the seeds have been extensively used in the classification of bean species and varieties. Hedrick (1931) and Bukasov (1930) have dealt sufficiently with the synonymy and history of bean classification.

Diagnostic characters of bean seeds have been studied individually from the standpoints of their genetics, physiology, and anatomy. The genetics of seed-coat coloration and variegation has been shown by Lamprecht (1939b), Smith (1939), and others to be quite complex. Smith found that six color genes plus modifiers were responsible for the red testa color of the common bean variety Red Kidney and that in other varieties no linkage was found among ground color, variegation color, and extent of eye color. Glossiness of seed coat was reported by Prakken (1937) as appearing to be genetically independent of factors for color and variegation of seed coat and pod and vegetative characters in crosses of *P. vulgaris*

varieties. However, as far as I am aware, no one has studied the dull testas of *P. acutifolius* seeds which is a diagnostic character of that species.

Shaw and Norton, according to Kooiman (1931), distinguished two classes of color in bean-seed coats, a red-and-purple, and a yellow-black. The pigments of the second were only slightly soluble in alcohol and alkali.

Use of the character of color quality introduces the problem of dealing with color change over time. Hedrick (1931) recognized this problem and chose to describe seed-coat color as it appeared in the first year subsequent to harvest. It is common to find dark brown specimens in old collections labeled "yellow beans," or to find familiar varieties of quite a different (dark) color than the fresh seed of the same variety. Skalinska (cited by Kooiman, 1931) showed that yellow and yellowish pigments oxidize to brown *in vitro*.

It is possible to divide color change into two physiological periods, that of ripening and during dry dormancy. Very young seeds are green and may remain so or may be tinged with green through maturity, as in French horticultural and certain greenish-white tepary beans. Loss of the chlorophyll may be accompanied by whiteness or lack of color which may persist or be quickly replaced by light tints of what would probably be the color at maturity. Coloring is first noticeable in the eye ring and then appears in the other parts of the testa, but darkening earlier with proximity to the placenta. Where there is patterning, it occurs as a sort of "developing out" process, reminding one of the development of a latent image on photographic paper. Streaks, spots, or other forms of variegation appear as islands of coloration on a light ground which itself may become colored subsequently. The color change which occurs during this period is largely quantitative, as indicated previously, but may proceed to a point where it appears to be qualitative. In the tropical black *P. vulgaris* the young rose-colored testa changes by the time of maturity to a purple so deep as to give the effect of black.

Subsequent to ripening, the rate of color change in the dry bean is slower but may be accelerated under certain conditions. The darkening of the light pink ground color of the seed coats of "Mexican pinto" (Type C13) beans has been observed to occur at a differential rate when the seeds were exposed to strong sunlight for several months. The sides of the seeds exposed to sunlight were much darker than the sides not so exposed. Samples of seeds which had been stored at room temperature for fifty to sixty-five years failed to show any color change when maintained at a temperature of 60° C. for thirty days, suggesting that limits of normal change had been reached at some time during this period.

It is sometimes difficult to distinguish what the color of the seed coat might be were it not for opacity. Thus, among black beans it is difficult to determine the nature of the blackness. The Hopi "Blue Dye" beans (Type C29), for example, are very dark blue while other "blacks" may be dark purples. In this study the use of color in the classification of seed types has been made with a realization of the changes in color which have undoubtedly occurred; nevertheless, all designations are based upon color quality at the time of examination. The larger color

TABLE II

DISTRIBUTION OF COMMON BEANS ON THE BASIS OF SEED-COAT COLOR PATTERNS

	Indian Southwest				Mexico*	Peru*	U. S. Commercial**
	All periods	Prehist. only	Contemp. only	Prehist. and Contemp.			
Self							
Number of types	19	6	7	6	162	43	117
Per cent	65	55	70	65	67	56	50
Variegated							
Number of types	11	5	3	3	84	34	118
Per cent	37	45	30	35	33	44	50

* Ditmer, *et al.* (1937).

** Hedrick (1931).

categories have been used rather than an exact description which would be subjective and not too meaningful.

Seed size in beans has been estimated (Kooiman, 1931) to be the result of the action of many genes which apparently affect the various dimensions equally. Thus within a population of seeds which have been selected for uniformity, the ratios between the dimensions of the larger seeds and those of the smaller seeds may be expected to vary little, providing all have reached normal maturity at the time of harvest and were grown under similar conditions. Within a given pod the largest seeds usually occupy a medial position and the smaller seeds are at either extremity. It would be well, then, to obtain seed samples for measurement from the entire contents of fully matured pods. Seed measurements, considered as reflections of the size and shape of seeds, represent the most useful set of criteria for the quantification of variation in these organs. But it should be recognized that seed dimensions may be differently affected by environmental conditions. Bean growers in humid eastern lands who plant disease-free seed from western arid lands note that the beans that they harvest are shorter and less flat than those which they planted (Hardenburg, 1942).

Prominence of the radicle and plumule located on the ventral (adaxial) margin of the seed, just anterior to the hilum, lends an apiculate appearance which is more frequent in some varieties than others. The extremes or ends of the seed are rounded in the lateral view, or one or both extremes of the seed may be truncate or appear to be flattened. If only one end is truncate, it is the posterior end and the apiculation may still be seen at the other extreme. In the pod, seeds are borne on the placenta along the ventral surface, with the growing parts of the embryo toward the apex. The scar, formed by abscission of the placenta and seed, is oriented longitudinally on the ventral margin of the seed, with the micropyle at

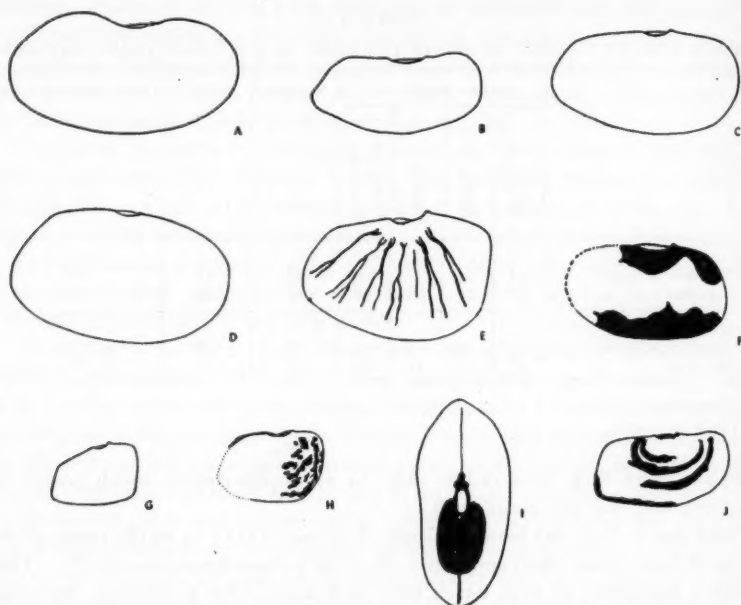


Fig. 1. Morphological characters of seeds: A, reniform; B, apiculate anterior end; C, rounded ends; D, entire; E, testa venation radiating from hilum of lima bean; F, mottled; G, truncate ends; H, flecked pattern; I, eyed; J, longitudinally striped.

the anterior end closest to the growing parts, and the paired elevated peaks of the testa, the caruncle, at the posterior end. It has been suggested that truncate seeds in *Phaseolus* are the results of: (a) interference by intralocular parenchyma tissue; (b) abutment of the seeds themselves. The first explanation assumes that mechanical pressure of the parenchyma is sufficient to limit the growth of a maturing seed and that it exerts its influence in some varieties but not others. In the second, truncate seeds are characteristic of some of the tepary beans the seeds of which are not at all appressed in the pod.

Technique.—All measurements of seed dimensions were taken with a vernier caliper and are given in the metric system. Each dimension was measured to give the maximum result so as to standardize the method and make repetition easier. In the actual measuring of length, for example, the apical anterior end was placed against the stationary jaw of the caliper and the sliding jaw closed until the posterior end was contacted. The jaws were then tightened to the extent that, when rotated on the apical end of the seed, the basal end would just slip by, neither sticking nor passing freely the surface of the movable jaw. An adequate degree of precision is obtained in this manner. Each seed was measured in its length from anterior to posterior extreme, in width from ventral to dorsal margin, and in thickness from one lateral surface to the other.

TABLE III
EXTERNAL SEED CHARACTERS OF FOUR SPECIES OF *PHASEOLUS*
WITH PARTICULAR REFERENCE TO SOUTHWESTERN VARIETIES

	<i>P. vulgaris</i>	<i>P. acutifolius</i>	<i>P. lunatus</i>	<i>P. coccineus</i>
Dimensions (cm.)				
Length	1.85-.74	1.20-.66	1.80-1.14	2.59-1.46
Width	1.08-.49	.78-.44	1.29-.85	1.48-1.13
Thickness	.85-.34	.56-.27	.60-.35	1.21-.72
Form	Various but seldom cuboid	Semi-spherical or flat, often cuboid with sharply truncate ends	Reniform, especially in larger-seeded forms with posterior end broad and truncate, anterior end attenuate in dorso-ventral plane	Various, usually semi-round in cross-section, ends round
Seed coat				
Venation	Reticulate or not apparent	Not apparent	Parallel and branching radially from hilum	Not apparent
Glossiness after polishing	Very glossy to moderately dull	Dull	Glossy to dull	Highly glossy
Hilum				
Caruncle*	Two prominences separate	Same as <i>P. vulgaris</i>	Prominences joined anteriorly	Same as <i>P. vulgaris</i>
Ring**	Elevated	Little elevated	Elevated	Elevated
Size	Roughly proportional to seed size	Not proportional to seed size, remains small in large-seeded types	Same as <i>P. vulgaris</i>	Same as <i>P. vulgaris</i>

* See fig. 2.

** Margin of testa encircling hilum.

In many cases among the archaeological collections it was possible, owing to the fragmentary or charred nature of the material, to measure only a few of the seeds in a collection.

It is possible to obtain a surface impression of the bean seed using any one of several acetone or ethyl acetate soluble plastics or Duco cement. Microscopic examination of a number of such impressions from seed coats of varieties of the four species dealt with here failed to show consistent differences which could be used in the classification of seeds.

DESCRIPTION OF BEAN TYPES

The use of scatter diagrams was adopted for graphic presentation of the data, as this method (Anderson, 1949, pp. 81-101) facilitates the comparison of several classes of data simultaneously. The source and size of each collection and its measurements are given in Table VII, as well as the number with reference to the typing system discussed previously. In Table IV the qualitative data—color, variegation, and form—are listed for each type. Table V includes the maximal, minimal, and median dimensions for each and the numbers of all collections represented by each type. Tables IV and V, along with figs. 1 and 2, provide all the characteristics of each type. A summation of species characteristics for Southwestern beans is found in Table III.

Association of Seed Characters.—The scatter diagrams (figs. 3-13) show that in the collections studied greater size in either seed length or width is associated with larger size in the other dimension. The degree of seed thickness has a less regular association with either of the other two dimensions than they have with one another. It may also be noted that variegated seed-coat patterns in the common bean also tend to accompany large seeds.

Seeds of the two principal species of *Phaseolus* dealt with here, *Phaseolus vulgaris* and *Phaseolus acutifolius* var. *latifolius*, form a discontinuous distribution readily seen in the scatter diagrams. Although this discontinuity is a reflection of seed dimensions, except for the patternless, or phenotypically patternless, white seeds common to both species, the color patterns are discontinuous also. It is the symbols mainly of the small white (Type C 6) seeds of *P. vulgaris* which cluster below the dimensional modes of this species and are found within the range of *P. acutifolius*, in the lower left-hand portion of the diagrams.

In addition to the small white type, the two curious small red (Type C20) and small flecked red (Type C12) *P. vulgaris* types overlap the teparies in size range. These were classed with *Phaseolus vulgaris* with some misgivings. However, should further study prove them to be variants of *P. acutifolius* rather than *P. vulgaris*, two interesting aspects will remain. First, the Murder House (Collection Number 195d) beans are from an area of tepary importance and common beans as well as lima occurrence; the other (Collection Number 206) are from the "Northern Periphery," an area of which the cultural and agricultural affinities are not yet well defined. Second, the seed characters show similarities to those of both

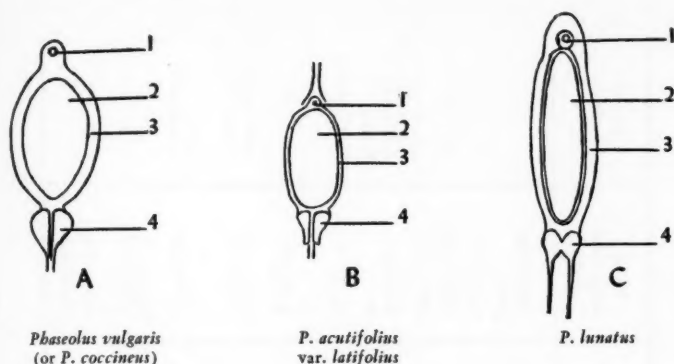


Fig. 2. Variation in hilum form: 1, micropyle; 2, placental scar; 3, hilum ring; 4, caruncle. Note incomplete separation of caruncle ridges in *P. lunatus*.

species to a greater extent than is usual. It is true that among white-seeded varieties it may be quite difficult to distinguish between *P. vulgaris* and *P. acutifolius* seeds, but this is not the case with the darker-colored and patterned seeds. It would be most interesting if viable seed of these types could be obtained and sown, to examine the vegetative characters of the plant.

The Earliest Bean Remains.—The earliest well-dated beans reported from Southwestern sites are those of the Mogollon in the pre-pottery or prior to 1 A. D. occupation level of Tularosa Cave (Martin *et al.*, 1952). This singular discovery offers sharp contrast to pre-pottery cultures of the Anasazi and Hohokam. In the Anasazi and Hohokam areas beans have not been found in cultures reliably dated as prior to Basketmaker III (ca. 500 A. D.) and from early Hohokam sites. In Tsegi Canyon in Northern Arizona, a prepottery Basketmaker site (Kidder and Guernsey, 1919), investigators failed to find beans, but they reported corn and other vegetal remains which evidence good preservation of artifacts of this sort. Beans, as well as squash and corn, were found in Tsegi Canyon sites subsequent to the introduction of pottery. Jones and Fonner reported fully on the vegetal remains of a number of Basketmaker II sites near Durango, Colorado (Morris, 1954), but they did not describe any beans. Gladwin's (1937) excavations at Snaketown, a Hohokam ruin now the site of a Pima Indian settlement, uncovered carbonized corn in houses dated at about 500 A. D. at the earliest. The only beans from this site were charred tepary and common beans dated at about 1000 A. D., which would correspond to Pueblo II in the Anasazi. The identification of these remains was made by Volney Jones (Castetter and Bell, 1942).

As has been indicated previously, in the quest for bean remains we are looking primarily for the very materials which the prehistoric Indians would have least wanted to leave behind. In times of food scarcity, single beans dropped on the floor of the dwelling may have been carefully retrieved. The most that can be said then of the occurrence of beans in the early periods is that, if present, they were not plentiful.

TABLE IV
MORPHOLOGY OF TYPES

Type	Color pattern	Ground color	Gloss**	Eye ring	Anterior end	Posterior end	Three-dimensional shape	Varietal similarity
*C1	Self	Orange-red to dark orange-red	+++	Dark	Truncate	Truncate	Cylindrical, entire	
C2	Self	White	++	Indistinct	Round	Round	Subreniform, semi-round	
C3	Self	Dark red-brown	++	Indistinct	Subapiculate to round	Round	Reniform, flat	Large Red Kidney
C5	Faint mottle	Dark red-brown	++	Dark	Apiculate	Round	Entire	
C6	Self	White	++	Indistinct	Subapiculate	Round	Entire	
C7	Self	Cream to yellow	+++	Indistinct	Subapiculate	Round	Entire, flat	
C8	Self	Dark red	++	Indistinct	Subapiculate	Round	Entire, flat	
C9	Self	White	++	Indistinct	Subapiculate	Round	Entire, semi-round	
C10	Self	Dark red-brown	++	Indistinct	Subapiculate	Round	Subreniform, cylindrical	

* C refers to common bean (*Phaseolus vulgaris*) types.

** +++++ Highly glossy seed coat.

+++ Moderately glossy seed coat.

++ Dull seed coat.

C11	Faint	Pale violet	++	Dark	Subapiculate	Round	Entire, semi-round
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C11	Faint longitudinal stripe	Pale violet to violet-brown	++	Dark	Subapiculate	Round	Entire, semi-round	<i>Garraseta</i> or Pinto
C11a	Distinct longitudinal stripe	Brown-violet	++	Dark	Subapiculate	Round	Entire, semi-round	
C12	Fleck	Dark red-brown	++	Dark	Round, tapered	Round to flattened	Entire, semi-round	Jacob's cattle bean; <i>Vaquita</i>
C13	Brown fleck and stripe	Pink	++	Dark	Subapiculate to apiculate	Round	Reniform, flat	
C14	Red or tan mottle	White to cream	++	Indistinct	Round	Round	Entire, semi-round	Red Mexican
C14a	Red or tan mottle	White to cream	++	Indistinct	Round to apiculate	Round	Reniform, flat	
C15	Self	Dark red	++	Dark	Subapiculate to apiculate	Round	Entire, flat	China Red Eye; Golden Wax
C16	Red-brown eye	White	++	Indistinct	Round	Round	Entire, semi-round	
C17	Self	Yellow-brown	+++	Dark	Subapiculate	Round	Subreniform to reniform	<i>Vayo</i> (<i>Bayo</i>)
C18	Self	Violet-brown	+++	Indistinct	Round	Round	Subreniform	
C19	Self or dark fleck	Dark red	++	Indistinct	Round	Round	Subreniform	Reniform
C19a	Dark fleck	Dark red-brown	++	Indistinct	Round to truncate	Round to truncate	Reniform	
C20	Self	Red-brown	++	Dark	Round	Round	Entire, semi-cylindrical	

TABLE IV (Continued)

Type	Color pattern	Ground color	Gloss**	Eye ring	Anterior end	Posterior end	Three-dimensional shape	Varietal similarity
C21	Self	Dark red	+++	Indistinct	Round	Round	Entire, semi-round	<i>Bolitas</i>
C22	Self	Yellow, brown, brown-red	+++	Dark	Round	Round	Entire, semi-round	
C23	Self	Brown	+++	Dark	Round	Round	Entire, semi-round	
C24	Brown eye-pattern superimposed on stripes	White	+++	Indistinct	Subapiculate	Round	Entire, semi-round	Dwarf Golden Wax
C25	Violet stripes	Pale violet	+++	Indistinct	Subapiculate	Round	Entire, semi-round	
C26	Dark red stripe	Red	++	Indistinct	Round	Round	Entire, flat	
C27	Self	White	+++	Indistinct	Round	Round	Entire, semi-cylindrical	
C28	Self	Pink	+++	Dark	Subapiculate	Round	Entire, flat	
C29	Self	Black (dark blue)	++	Indistinct	Round	Round to flat	Entire, flat	
C30	Self	Black	+++	Indistinct	Apiculate	Round to truncate	Entire, cylindrical	
*L1	Self	Dark purple	++	Indistinct	Round to subapiculate	Truncate	Entire	
L2	Self	White	++	Indistinct	Round	Round	Entire	

*L refers to lima bean (*Phaseolus lunatus*) types.

L3	Dark fleck	Brown	++	Indistinct	Subapiculate to round	Round	Entire	Jackson's Wonder
L4	Dark fleck and stripe	Dark red	++	Indistinct	Round	Round	Entire	
L5	Light tan eye pattern suffused	Dark brown	++	Indistinct	Subapiculate to round	Truncate	Entire	
*T1	Self	Red-brown	+	Indistinct	Subapiculate	Round	Entire, semi-round	
T2	Black fleck	Tan	+	Black	Round	Truncate	Entire, flat	
T3	Self	White	+	Indistinct	Round	Round	Semi-round	
T4	Self or brown fleck	Orange-brown	+	Indistinct	Truncate	Truncate to round	Entire, flat	
T5	Self	Brown	+	Dark	Truncate	Truncate	Entire	
T6	Self	White	+	Indistinct	Round	Round	Entire, semi-round	
T7	Black flecks almost completely cover ground	Tan	+	Indistinct	Truncate	Truncate	Entire, flat, cuboid	
T8	Dark fleck	Red-brown	+	Indistinct		Round	Semi-round	
*R1	Self	White	+++	Indistinct	Round	Round	Semi-round	
R2	Purple mottle and fleck	White, violet	+++	Indistinct	Round	Round	Semi-round	

*T refers to tepary bean (*Phaseolus acutifolius*) types.*R refers to runner bean (*Phaseolus coccineus*) types.

The Mogollon furnishes a situation which may help to explain both the spotty occurrence of early beans in other areas and the clear regional differentiation of varieties in later times. The peoples of Cordova and Tularosa Caves (Martin *et al.*, 1952) were contemporaries living in the Reserve, New Mexico, region. They shared many basic cultural traits, but the people of the Cordova Cave site relied more upon hunting than did those of Tularosa Cave. Bean remains were relatively abundant in the latter site, but only a single bean and one pod fragment were found in Cordova Cave, and vegetal materials from other pre-1200 Mogollon sites indicate non-importance of bean cultivation. If the same kind of distribution—few bean-growing and many non-bean growing communities contemporaneous in the same region—occurred in the Basketmaker Anasazi region, it may be said that early Basketmaker beans have not yet been found but that they do exist. With greater attention on the part of persons trained to recognize and identify charred seeds and other remains, more Basketmaker beans and those of other pre-pottery peoples might be recovered.

Varietal Change.—On the basis of seed characters the earliest beans of Tularosa Cave do not differ in any way which could be interpreted as part of an evolutionary sequence from the most recent beans of Tularosa Cave, despite the difference of over 1,000 years. This is generally true of Southwestern bean remains. Changes in cultivated prehistoric beans of the Southwest which are correlated with time changes are those which show the introduction of new species or varieties from an older to a newer region or culture. The question of evolutionary change in beans under domestication may be reopened with the anatomical study of bean-pod remains. However, it can be said that the apparent lack of change of beans under domestication in the Southwest is further indication that development from the wild kinds occurred elsewhere or outside of the Southwest, and at an earlier date.

Bean Preparation.—Among the beans collected from contemporary Indian peoples there is in the Museum of Anthropology of the University of California at Berkeley a sample (Collection No. 117a) of parched beans labeled "parched small white *P. vulgaris*" obtained from Yuma Indians.³ A collection of more than one quart of common beans from Kiet Siel, a Pueblo III ruin in Tsegi Canyon, northern Arizona, was examined at the Museum of Northern Arizona and found to have been lightly toasted. This sample, as well as the preceding one, emits a characteristic odor; seeds which obviously were originally white are tanned irregularly, and cotyledons of the white seeds which have the most tanned testas are browner than those of less tanned lighter seeds. Seeds of this collection are described in Table VII Nos. 188, 189, 190, 191, 192, 193, 194a, 194b.

³ These, however, are teparies (Type T 3) rather than common beans.

TABLE V. DIMENSIONS OF SEED TYPES

Type	Range of Measurements (cm.)						Median of Measurements		
	Maximum			Minimum					
	Length	Width	Thickness	Length	Width	Thickness	Length	Width	Thickness
C1	1.69	.94	.67	1.05	.61	.48	1.30	.71	.57
C2	1.49	.87	.66	1.10	.64	.44	1.25	.73	.55
C3	1.67	.92	.66	1.07	.68	.42	1.43	.80	.57
C5	1.63	.95	.70	1.13	.76	.47	1.35	.85	.57
C6	1.28	.75	.55	.79	.50	.37	.99	.60	.48
C7	1.35	.90	.68	1.15	.73	.50	1.29	.87	.51
C8	1.61	1.03	.56	1.43	.91	.49	1.49	.99	.54
C9	1.50	.91	.68	1.05	.66	.36	1.34	.83	.57
C10	1.69	.80	.70	1.61	.79	.65	2 seeds sep. coll.	2 seeds sep. coll.	2 seeds sep. coll.
C11	1.73	.97	.73	1.20	.66	.45	1.42	.81	.61
C11a	1.16	.78	.60	1.09	.71	.44	2 seeds sep. coll.	2 seeds sep. coll.	2 seeds sep. coll.
C12	.89	.63	.50	.74	.52	.34	.84	.62	.48
C13	1.71	.89	.68	1.08	.67	.41	1.26	.78	.54
C14	1.76	.95	.68	1.04	.65	.39	1.32	.81	.56
C14a	1.26	.92	.74	1.03	.66	.55	1.16	.78	.64
C15	1.38	.84	.59	1.07	.65	.42	1.08	.65	.43
C16	1.22	.70	.59	1.00	.68	.57	2 seeds	2 seeds	?
C17	1.65	.92	.64	1.11	.64	.43	1.41	.81	.53
C18	1.70	.87	.67	1.36	.68	.47	1.46	.76	.54
C19	1.65	.90	.59	1.33	.70	.44	1.50	.72	.51
C19a	1.85	.94	.67	1.39	.63	.49	1.58	.85	.58
C20	.94	.62	.45	.87	.56	.40	.93	.59	.43
C21	1.22	.86	.76	1.19	.80	.62	1.20	.82	.69
C22	1.38	.83	.66	1.03	.63	.46	1.22	.74	.55
C23	1.38	.78	.57	.95	.60	.42	1.08	.68	.47
C24	1.51	1.08	.85	1.26	.75	.63	1.44	.93	.73
C25	1 seed						1.14	.86	.68
C26	1.54	.84	.63	1.28	.74	.41	1.38	.80	.48
C27	.86	.58	.42	.77	.49	.36	.79	.53	.39
C28	1.41	.86	.78	1.00	.66	.43	1.18	.74	.50
C29	1.54	.87	.60	1.10	.70	.41	1.26	.76	.52
C30	1.34	.62	.69	1.34	.60	.58	2 seeds	2 seeds	2 seeds
L1	1.64	1.16	.60	1.29	.90	.40	1.47	1.03	.53
L2	1.58	1.11	.58	1.18	.85	.41	1.37	.93	.52
L3	1.80	1.20	.62	1.37	.95	.42	1.58	1.08	.55
L4	1.76	1.29	.55	1.51	1.05	.49	1.62	1.14	.52
L5	1.48	1.04	.49	1.14	.91	.35	1.37	.91	.44
T1	1 seed						.67	.52	.37
T2	1 seed						.70	.54	.27
T3	1.19	.70	.50	.87	.57	.37	1.00	.65	.43
T4	1.20	.78	.45	.81	.50	.31	1.03	.67	.41
T5	1.05	.69	.47	.66	.44	.28	.89	.60	.39
T6	.98	.69	.56	.73	.46	.30	.84	.55	.41
T7	1.11	.76	.49	.85	.61	.35	1.02	.68	.42
T8	1 seed						.82	.55	.36
R1	2.15	1.48	1.20	1.46	1.20	.94	1.90	1.28	1.13
R2	2.39	1.47	1.21	1.71	1.13	.72	1.99	1.32	.98

West (1947) reports an interesting practice of certain Tarascan Indians which may be related to this problem. A variety of *P. coccineus*, grown only by the more conservative people and tended mainly by the women in their house gardens, is used in special dishes, among which is a *pinole* made with a special "black maize." The corn is said to be toasted, but the preparation of the beans prior to grinding is not indicated. This practice was not found among non-Indian (Ladinoized) residents of the area.

Whiting (1950) reported that the Hopi parch white and mottled teparies before cooking. This treatment of the white tepary (or in its absence, "other white beans") is noted in connection with the breaking of a ritual fast by priests.

Although the material from Kiet Siel, which, according to tree-rings dates back to as early as 1106 A. D. and as late as 1221 A. D. (McGregor, 1934), contains the oldest sample of parched beans yet seen, parching may be supposed to have been practiced earlier and may well have formed the basis of dry-bean use for protein in pre-pottery times.

Parching of dry mature beans for use in such foods as *pinole* may have once been important and widespread, but now parching has been all but superseded by boiling. Ritual food preparations, such as those referred to above, may be the most likely conditions under which an ancient manner of food use might be retained although reinterpreted.

DISTRIBUTION OF BEAN TYPES

Tepary Beans.—The greater importance of tepary bean cultivation in the most arid region of the Southwest, that of the Pima and Papago (Hohokam), has been shown among the contemporary Indians by Freeman (1912), and Castetter and Bell (1942). Fewer tepary varieties than the forty described by Freeman were encountered in the collections available for this study. However, collections from the Pima and Papago and the Colorado River tribes (Table VII and figs 3-13) substantiate the extensive use of teparies by these tribes in recent historic times.

Efforts by the author to obtain teparies in 1953 and 1954 on the Pima and Papago Reservation at Sells and Ajo, Arizona, and from trading posts on the Cocopa Reservation were unsuccessful. Local residents said that droughts of recent years and availability of the popular pink beans (Type C26) may explain the general decline of old bean varieties among the Indians.

As the agronomic, botanic, and ethnologic writings on the tepary invariably refer to the drought and heat resistance of this species, some of the problems relating to the history of its domestication should be discussed.

Freeman (1912) first reported the superiority of yield of teparies over common bean varieties under dry-land and irrigated conditions in Arizona. Good yields under dry-land conditions have been obtained as far north as Colorado, where the Redfield tepary out-yielded the high-producing Pinto common bean (Brandon, 1943). The paucity of prehistoric tepary bean remains outside of the southern

Arizona-New Mexico region is not to be explained by any unsuitability of varieties of this species to the northern, Anasazi, region.

If the tepary bean is a domesticate of the Hohokam or other peoples of the Sonoran Desert region, then its involvement with the history of these people may help to account for its importance among them, while the restricted occurrence in the Anasazi and Mogollon may be attributed to partial unacceptability of teparies to peoples long accustomed to common beans. If, on the other hand, tepary beans were domesticated far in the south of Mexico, they must have found acceptance among many peoples who were familiar with common beans, and probably lima and runner beans as well, before reaching the Southwest. Although early Hohokam archaeological sites are not good ones for the preservation of vegetal materials, distribution patterns of teparies (Table VI) suggest their late introduction and diffusion in the Southwest.

The question of origin of the tepary bean will be solved neither by De Candolle's criterion of the location of related forms in the wild state nor by Vavilov's "center of varietal diversity" hypothesis nor will studies of archaeological materials supply all the needed information to elucidate the role of the tepary bean in Southwestern prehistory. It is necessary to know the source of variability and the history of domestication of this plant.

Freeman (1912) supposed that the tepary bean was domesticated from very small, angular-seeded, broad-leaved indigenous forms (*P. acutifolius* var. *latifolius*) growing in the watered canyons of the Sonoran Desert and that selections from these types yielded the many varieties which he recognized among contemporary cultigens. Freeman made no estimate of the time period necessary for the great increase in seed size and change in form from the wild to the domesticated forms nor were the mechanics of the change indicated. Carter (1945) accepted Freeman's hypothesis, and used the element of time as an argument for greater antiquity of man in the Southwest. Castetter and Bell (1942) rejected Freeman's conclusion on the basis of the great difference in size and form between the cultivated and the non-cultivated *P. acutifolius* var. *latifolius*, and on the fact that the earliest prehistoric beans which they had seen in no way resemble any of the non-cultivated beans but can be equated with modern cultivated varieties. The latter view concerning the identity of the prehistoric and modern materials is supported by data presented in this paper (Table VII). It would be strange indeed if beans of the already-high agricultural cultures which supply the earliest material of this sort were to be of a primitive type. Cultivation under irrigation of the small, angular-seeded wild teparies (Castetter and Bell, 1942) did not change the seed characters.

Selection and cultivation without accompanying or preceding changes in the germ-plasm could hardly account for the differences between Southwestern cultivated and indigenous teparies. A source of change might be mutation, but seed size is not a single-gene character; rather it appears, as indicated previously, to be the result of interaction among several genes directly, while many other characters are involved indirectly. The rates of mutation at these loci are not known, but extremely careful selection and breeding, as well as a very long time, would

TABLE VI. OCCURRENCE OF TYPES

Type	Prehistoric					Contemporary					
	Mogollon	San Juan Anasazi Mesa Verde	Northern Arizona Anasazi	Verde Valley Hohokam-Anasazi	Northern Periphery	Rio Grande Pueblos	Hopi	Zuni	Navajo	Arizona Piman	Colorado River Yuman
*C1	x	x	x	x		x	x				
C2	x		x				x				
C3	x			x	x		x	x			
C4	x										
C5	x										
C6	x								x		x
C7	x										
C8	x										
C9	x						x		x		
C10	x										
C11		x	x	x	x		x	x			x
C11a			x	x	x						
C12				x	x	x					
C13				x		x	x		x	x	
C14			x	x		x	x	x	x		
C14a			x	x		x	x				
C15	x			x	x	x					
C16	x										
C17							x	x			
C18				x		x	x	x		x	x
C19	x		x			x					
C19a			x		x						
C20				x							
C21				x							
C22						x					
C23						x			x		
C24								x			
C25							x				
C26						x	x				
C27											
C28							x			x	
C29							x				
C30							x				
*L1				x			x				
L2							x				
L3							x				x
L4							x				
L5							x				
L6							x				
*T1				x							
T2						x					
T3						x	x				
T4						x					
T5				x				x		x	
T6				x			x			x	
T7							x				
T8				x							
*R1							x				
R2							x				

* C refers to common bean (*Phaseolus vulgaris*) types; L, to lima bean (*Phaseolus lunatus*) types; T, to tepary bean (*Phaseolus acutifolius*) types; R, to runner bean (*Phaseolus coccineus*) types.

probably be necessary for the effect of any such mutations to be expressed phenotypically. A more likely source of variability in tepary beans is hybridization with some other related species. This process is certainly suggested by Freytag's demonstration (unpublished thesis) of the effect of introgressive hybridization in common beans.

Unfortunately, very little genetic or even breeding work has been done on teparies, and no interspecific crosses have been reported. Teparies in the Southwest, and probably common and lima beans as well under arid conditions, are almost entirely self-fertilizing owing to very early pollination in the unopened flower bud. A thorough study of cultivated and non-cultivated *P. acutifolius* and *P. acutifolius* var. *latifolius* and suspected hybridizing species is necessary to indicate what the source or sources of variability in this species might be. Also of importance would be the determination of the geography and ecology of hybridization in this species.

Southwestern and Other Bean Assemblages Compared.—The grouping of bean types presented in Table II suggested that large geographic areas have characteristic bean assemblages. At present, it is not possible to give more significance to the distributional patterns other than to indicate that they exist. Whether the cultural or natural agencies shaping the distribution are selective or non-selective is likewise obscure; however, some of the selective factors which might be worthy of further investigation are discussed below. Data are drawn from Southwestern materials examined by the author, from the reports of the Russian investigators (Ditmer *et al.*, 1937), and from Hedrick's study (1931) of the United States commercial beans.

It will be noted that never does the percentage of variegated-seeded forms exceed that of the corresponding self-colored forms. The highest percentage of variegated forms, 50 per cent in the United States, reaches that figure largely because of the great diversity and number of variegated forms among the bush snap beans. Many of these are introductions from Europe, and the needs of the canning industry and available year-round markets have stimulated the use of many varieties with differing horticultural characteristics. Diversity in seed characteristics here is incidental. Among the bush snap beans described by Hedrick (about 127 named varieties), 55 per cent have variegated seed coats. In all other varieties there are considerably fewer variegated forms than there are self-colored ones. The percentage of strictly prehistoric types of the Southwest most closely approximates Peruvian distribution, while the totals for the Southwest, including prehistoric, contemporary, or both periods combined, are most like the Mexican distribution and very little like the 1:1 ratio for the United States. The high percentage of self-colored beans, which occurs only in contemporary Southwestern Indian cultures, and the fact that few of these are found as field beans in other more humid parts of the United States, indicate an influx during historic times of self-colored beans. The trend in the Southwest thus has been toward absolute and percentage reductions in the numbers of variegated bean types and a corresponding increase

in self-colored types which are dry shell beans, except for the Hopi "Black" string bean (Type C30). The importance of the Pinto or *Garrañata* bean (Type C13), a variegated dry shell bean, is also recent.

Freytag (unpublished thesis) states that Latin American beans used in the dry-shell stage over a wide area are likely to be self-colored and not of an unusual shape, while variegated or odd-shaped dry-shell types are of restricted distribution. These selective factors are apparently not operative in snap beans as such beans are consumed before seed maturity. This seems to be true in the United States, as variegated dry beans, with the exception of the pinto varieties which are used for Mexican or Texas style dishes, are of quite restricted distribution.

Interpretations of Bean Distribution:—

Three fairly distinct regions can be outlined in the prehistoric Southwest for the cultivation of beans. So far as is possible, the source of beans, the dates of their introduction, cultural affinities, and movements within the Southwest will be indicated.

It was hypothesized that the distribution of cultivated beans in the prehistoric Southwest would show a diversity resulting from differing climatic and ecological conditions and from differences in culture history. The influence of the environment and some ethnobotanical factors such as food preparation have already been discussed. A division of the Southwest following three main cultural groupings was adopted for the organization of bean distributions into regions. These regions can be compared with those of other plant materials and culture traits.

1. Mogollon:—

Although beans are known only from a few sites in a limited area of the Mogollon, it is evident that the cultivation of the common bean in this area preceded the introduction of pottery. The number of pre-pottery beans from Tularosa Cave is small but the prepottery context is clear, and it may be stated that by 300 B. C. common beans, along with maize and pepo squash, were being cultivated by Mogollon Peoples. The number of communities or settlements cultivating beans at this time cannot be estimated, but it is probable that it was not large, as none of the Mimbres River sites nor Cordova Cave, which is even closer to Tularosa Cave, show any evidence of important bean cultivation. The open sites of Higgins Flat and Hinkle Park, which appear to be immediately subsequent to and in the same cultural tradition as the Tularosa Cave, indicate that bean culture continued with common types similar to those of Tularosa Cave and may indicate a greater extent of bean growing. Since tepary beans do not occur in the Mogollon before 1100 A. D. (Higgins Flat), they may be regarded as introductions from the Hohokam; there seems to be no prior association of *P. acutifolius* in the Mogollon with *Cucurbita pepo* of which abundant remains were found in Tularosa Cave.

2. *Hohokam*:—

As noted previously, vegetal materials are absent in most early Hohokam sites. While this lack may be due to poor conditions of preservation, beans first appear in the Sacaton phase, or about 1,000 A. D. at Snaketown. The charred tepary and common beans identified by Volney Jones are said by Castetter and Bell (1942, p. 32) to constitute these remains, and may be the earliest record of tepary beans in the whole Southwest as well as in the Hohokam. Not enough evidence is available at present to warrant conclusions as to approximate dates for the introduction of cultivated beans to the Hohokam, nor is it possible to say whether beans were utilized in pre-pottery times in this region. Since the distinguishing feature in Hohokam beans seems to be that they are tepary varieties, which may represent a response to climatic rather than cultural factors, a long history of selection for varietal preference need not be hypothesized. The climatic conditions of southern and southwestern Arizona would quickly encourage the cultivation of tepary beans after their introduction. If domestication of the tepary occurred in the region of the Hohokam, it is not now possible to estimate when the cultivated varieties emerged as different enough from the indigenous forms to be differentiated from them. The Hohokam ruins which have provided the best bean material are later than 1,000 A. D., and usually they show the influence of the Anasazi in several aspects of culture. Montezuma's Castle (1300 A. D., Collection Nos. 201-205a), located in the Verde Valley, central Arizona, is listed by Carter (1945, p. 24) as a Pueblo III, Little Colorado River site, among those sites demonstrating the advance of *Curcubita moschata* from the Mesa Verde region to the south and west into the area of the Hohokam. In this site only have been found uncharred, definitely identifiable bean remains representing the three species known to occur in the prehistoric Southwest. A mixture of bean assemblages of the Hohokam and Anasazi are evident in the teparies, and limas from the Hohokam and the characteristic striped violet common bean (Type C11) of the Anasazi. Other sites of the Verde Valley evidence the influence of the Anasazi bean types rather than those of Mogollon.

The lima bean appears to be characteristic of the Hohokam. Mackie (1943) has the theory that lima beans entered the Southwest by way of western Mexico and the Colorado River tribes into the Hohokam area. He discounts the likelihood of the eastern Mexico-Sierra Madre Oriental corridor as unsuitable because of excessively humid conditions. Mackie also finds that the Hopi lima beans and the beans of eastern United States Indian groups are identical and suggests that the eastern limas are an extension across the Mississippi Valley of the Hopi varieties. Carter considers that the absence of native archaeological lima beans east of the Hopi mesas until Pine Bluffs, Arkansas, necessitates an eastern Mexico-Texas corridor to the east. I have found, in undated excavated material from Sunny Glen Cave, Texas (Anonymous, 1932), and in sites from Tamaulipas, Mexico, (specimens and personal correspondence from McNeish, in 1955), extensive remains of common bean pods and a few seeds. The lima bean pods found among

the vegetal remains from Tamaulipas strengthen the eastern Mexico corridor hypothesis.

Lima beans are known from relatively few prehistoric Southwestern sites; these are discussed by Steen and Jones (1941) and mapped by Carter (1945).⁴ The sites from which these beans are known are in the Verde Valley which shows an admixture of Hohokam with other cultures. However, since the lima beans are found neither in the Mogollon nor northern Anasazi sites, their relationship to the Hohokam seems clear.

3. *Anasazi*:—

In the scatter diagrams the bean remains of the Mesa Verde pueblos are separated from those of the northern Arizona Anasazi to emphasize varietal diversity. In this study only two types are recognized as present among the Mesa Verde pueblos, and the larger number of types found in the ruins of northern Arizona. The frequency of occurrence of the striped, violet common bean, type C11, in both the northern Arizona and Mesa Verde Anasazi, and its rarity elsewhere unifies these two regions with regard to bean distribution.

Collections of beans from Zion National Monument in southeastern Utah examined at the Museum of Anthropology, University of Michigan, provide evidence which helps to clarify the relationship of Northern Periphery beans to those of the Anasazi. Although the stratigraphy has been disturbed, habitation of the site probably extended from Basketmaker II times until about 1150 A. D. (correspondence from A. H. Schroeder to Volney H. Jones). Among these well-preserved beans are to be found: types C11, C15, C12, C19a, and possibly C1—collection numbers 232–236 respectively.

Jones' description (Brew, 1946) of charred beans (limas, common beans, and others whose dimensions fell within those for Southwestern teparies) from the Alkali Ridge site in southeastern Utah may indicate early agricultural influence from the south. Since the beans of Mesa Verde in southwestern Colorado—an occupied area showing many cultural affinities with Alkali Ridge (Brew, 1946)—are all common beans, none of which even in the charred condition could be mistaken for lima beans or teparies, Northern Periphery and Anasazi beans do not correspond completely. The presence of the small red, flecked bean, type C12 in the Zion material (the small charred seeds found by Jones in the Alkali Ridge collection may be of this type), links the Verde Valley (collection no. 162a) with southeastern Nevada Virgin River sites (collection nos. 206, 206a), said by Reed (1954) to be Pueblo II outliers of Anasazi culture, and with southeastern Utah.

The Verde Valley and Anasazi, then, appear to have had beans in common with those of the Northern Periphery. Although Northern Periphery materials discussed in this paper are probably earlier than the Anasazi beans, which are mostly

⁴ The charred seeds cited by Carter as those of lima beans from the Hodges site in south-central Arizona are actually *Canavalia ensiformis*, as evidenced by the broad hilums which are about half the length of the entire seed.

from Pueblo III, there is little to indicate a direct movement of agricultural complexes to the Anasazi from the south by way of Nevada and Utah. However, it does seem evident that the characteristic bean—C11—of the Anasazi did derive from the Northern Periphery or, at least, although rare in the Anasazi, was common to both regions in pre-pottery times.

In Basketmaker III times (Wormington, 1955) and later culture periods, many traits point to a close relationship between the Northern Periphery and the San Juan Anasazi. Among such evidence is the Central Mexican type of corn found in prehistoric sites of southeastern Utah (Wormington, *op. cit.*). This type of corn was described from the vegetal remains of Alkali Ridge by Anderson (1944) and, with other artifacts, strongly suggest Mexican influence. However, neither Nickerson (Wormington, 1955) nor Carter (1945) believed the corn to have come directly through the Arizona Pueblo, Mogollon, or Hohokam areas, but both authors consider a plains route as a likely alternative. The high row-number corn of many early Southwestern sites, however, may indicate an early widespread distribution of the Central Mexican corn. Evidence provided by bean remains supports early southern rather than eastern agricultural influence.

The Existence of Bean Areas.—Two theories may be advanced for the existence of bean areas and their coincidence with culture areas in the Southwest.

One theory would involve an early introduction of beans to the Mogollon and a later introduction to the Anasazi of varieties distinct from those found in the Mogollon and unlike those found in the Hohokam. Thus the late introduction to the Anasazi would not have come by way of either of these two regions and therefore hardly could have come from Mexico directly except by way of eastern Mexico and Texas. There are no dated remains to support this. An indirect route from the Mexican-Central American center by way of the Caribbean, the Gulf Coast, and eastern United States cannot yet be properly evaluated, but in the opinion of the author this remains an unlikely route for reasons of cultural affinities and plant geography.

A more likely theory would assume the early entrance and widespread distribution of beans throughout the Southwest but their adoption and culture by a relatively small number of communities. This might explain both their presence and their rarity in Basketmaker sites. The early beans thus could have been both widespread and varietically more uniform than indicated by the later materials. These later materials, as yet the only ones available to us, would have come from a time postdating an intensification of bean culture, a time more likely to have left bean remains simply because more people were growing them. During the period between the introduction or introductions of beans to the Southwest and the beginning of their more general cultivation, differentiation of types on the basis of local or regional cultural preferences and regional climatic and edaphic conditions would have occurred.

CONTEMPORARY BEANS

Early Spanish and later Anglo-American contacts brought new plants to the Indian farmers, some of which became important and sometimes basic crops. During the historic period contact among Pueblo peoples has been of more than a casual or even trading nature, and introductions of Peruvian beans by way of California and United States commercial varieties have occurred.

1. *Hopi Beans*:—

The assemblage of Hopi bean types (Table VI and fig. 9) appears to be most closely related to that of the Verde Valley among the prehistoric groups. Beans of the Verde Valley are the most diverse of the prehistoric groups and seem to be composed of types which had come from the northern Anasazi, the Hohokam, and the Reserve, New Mexico, Mogollon area. The mixture of types and species found in the Verde Valley is not to be found in any one of the three great culture groupings discussed in this paper.

In addition to the "old" beans which appear to have come down to the Hopi from Verde Valley peoples, newer varieties which do not appear in the archaeological record have been adopted by the Hopi. These new varieties have had several sources. The Pinto beans (Type C13) as known in the United States are only a few variants of the *Garrapata* or tick bean group, which is highly diverse and well distributed in northern Mexico (Collections of Oficina de Estudios Especiales, Secretaria de Agricultura y Ganaderia, Chapingo, Mexico). The occurrence in the Verde Valley (Collection number 164) of the only prehistoric collection of Pinto beans indicates a distribution limited to a single variety of the *Garrapata* group as well as a rather restricted range of cultivation. The highly important and widespread Pinto bean varieties now in use among most Southwest Indians probably represent historic introduction of *Garrapata* varieties from Mexico as well as a possible expansion of cultivation of the Verde Valley type. The arrival of these beans among the Hopi and other Indians may have been early, with the Spanish missionaries, or with later Mexican contacts.

Two other types which have become important in the contemporary Southwest but which are absent in prehistoric collections are the Pink and Bayo types (Types C28 and C17, respectively) both of which are found among the Hopi. Hendry (1918) states that the Pink bean is Chilean in origin, and that a translation of its northern Mexican name is "White man's bean." The date of introduction of the Pink bean is not known, and whether it arrived overland by way of Mexico, or sailing vessel by way of California, is equally obscure. The Bayo types which are found among the Zuni and the Hopi are said by Hendry to have come to California prior to 1850 in sailing vessels from Chile and to have become well established in the Southwest. These also have become widespread in western Mexico.

2. *Zuni Beans*:—

It is probable that the collections of Zuni beans studied are less complete than those of the Hopi, and the same may be said for other contemporary Southwestern

groups. The Zuni types, without important exception, may be the same as the Hopi types (See Table VI) of common beans. The fact that only one tepary type and no lima beans occurred among the Zuni indicates less influence of the Verde Valley, and ultimately Hohokam bean assemblage, upon the Zuni than on the Hopi.

3. Rio Grande Pueblo Beans:—

From the scatter-diagrams it may be seen that the common beans of the Rio Grande Pueblos are, as a group, smaller and less-variegated than the other common bean groups (figs. 3-13). There is no information concerning prehistoric beans of the Rio Grande peoples, but it may be that during the long Spanish rule of the Rio Grande Pueblos these beans were introduced from Mexico.

4. Navajo Beans:—

It has been often said that Navajo agriculture was derived from the Pueblos, particularly from the Hopi. There is nothing in the Navajo bean assemblage to indicate that Navajo beans were not derived from the Hopi or, in the case of the newer beans (e.g. the Pinto), from the same source as that of the Hopi.

5. Piman and Yuman Beans:—

Beans of the Arizona Piman and Colorado River Yuman peoples are most like those of that part of the Verde Valley which was probably most influenced by the Hohokam. There can be little doubt that the tepary beans of the Piman and Yuman groups are directly related to beans of the ancient Hohokam. If lima beans were a prehistoric Hohokam crop, as is believed by the author, one would expect them to have persisted at least among the Pima. However, little remains of the traditional crop varieties. It is extremely difficult to obtain corn of older non-commercial types from the Pima, and beans other than the commercial types are even harder to find. In addition to the difficult farming conditions of recent drought years, it is probable that the importance of cash-cropping among these people since the mid-nineteenth century has operated against retention of the older crops, especially the poorly marketable tepary bean and dark-colored lima beans.

CONCLUSIONS

A complex assortment of varieties of *Phaseolus vulgaris* began to enter the Southwest at least 2,000 years ago. Their appearance in the archaeological record of the Mogollon in west-central New Mexico was prior to the introduction of pottery, while in the Anasazi area of northern Arizona the bean record begins at about the same time as the introduction of pottery, and in the Hohokam of southern Arizona, subsequent to pottery. The existence of well-defined prehistoric bean areas and the probability that beans were prepared for eating by parching and grinding in early non-pottery times suggest that beans were cultivated in the Southwest for a longer time than indicated by the now available archaeological

materials. The parching and grinding of mature bean seeds may have been practiced by relatively few communities in a given area for a long time before culture changes which are not now precisely known stimulated the general adoption of beans. The early but restricted use would have afforded ample time for the differentiation and selection of varieties characteristic of particular areas.

Lima beans probably entered the Southwest by way of both the Sonoran and eastern Mexican corridors but at a later date than the common beans; their earliest record is found in 13th or 14th century ruins. Lima beans remained restricted to the central and north-central parts of Arizona and nowhere became as important as common beans.

Phaseolus acutifolius appeared as an important bean only in extremely arid southern Arizona, having come into use by the Indians of that region sometime prior to 900 A. D. There is insufficient evidence as yet to locate the center of domestication of the tepary bean; it may have been a domesticate of Sonoran Desert Indians or of peoples in the southern part of Mexico.

The presence of *P. coccineus* in prehistoric Southwest cultures has not been established, and its contemporary cultivation, limited to the Hopi, does not indicate a position of importance for these beans.

The absence of change indicative of evolution under domestication in prehistoric beans is attributed in part to the fact that the center of origin of the cultigens represented is far removed from the Southwest, and in part that beans were cultivated previous to the period for which archaeological material is available.

Among the prehistoric cultures, large, variegated common beans with a high frequency of a violet bean (Types C11 and C11a, which is distinctly or indistinctly longitudinally striped) are characteristic of the prehistoric Anasazi cultural division. The tepary bean is of greatest importance in the Hohokam region, while the Mogollon culture division is characterized by large-seeded non-variegated common beans and the absence of the striped violet bean of the Anasazi. Central Arizona, including the Verde Valley, shows evidence of the bean influence of the Hohokam and Anasazi and has the most varied assortment of beans, with common, lima, and tepary beans present.

The prehistoric source of the contemporary Hopi beans appears to have been the Verde Valley while the beans of the Pima and Papago tribes came from southern Arizona. In addition to the prehistoric bean types, contemporary Southwestern Indians have acquired beans from Mexico, Peru, and from commercial seed sources in historic times.

SUMMARY

1. Collections of cultivated beans from contemporary Southwest Indian peoples and bean remains from prehistoric sites in the same area were studied.
2. On the basis of external seed morphology and anatomy a series of cultivated bean types is described in tabular and graphic forms. The types have about the same taxonomic significance as named horticultural varieties. Thirty-two common

bean (*P. vulgaris*) types are recognized and described for the Southwest. Of these, thirteen have been found only among prehistoric remains, ten occur only in contemporary collections and nine have been found among both prehistoric and contemporary collections. Eight tepary bean (*P. acutifolius* var. *latifolius*) types are recognized from prehistoric and contemporary collections, and five lima bean (*P. lunatus*), and two runner bean (*P. coccineus*) types are recognized and described from contemporary collections only.

3. Using the criteria for classification of bean types as presented in this paper, new materials may be compared to the existing Southwestern types. With this basis for comparison bean collections from different cultural and temporal contexts can be related and the history of bean domestication, variation, and use patterns may come to be better understood.

4. Bean areas are defined on the basis of distribution of the types; prehistoric and contemporary divisions are made according to temporal distribution. The areas outlined correspond to Indian cultural divisions and to climatic conditions.

5. It is suggested that parching and grinding of mature bean seeds was an early method of preparation for food and that the role of beans in the diet was as a source of protein to supplement animal and complement maize protein.

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KEY TO SCATTER DIAGRAMS, FIGS. 3-13

PHASEOLUS SPECIES	SEED THICKNESS	COLOR	VARIATION
<u>P. VILGARIS</u>	LESS THAN .55 CM.	WHITE	EYE PATTERN
<u>P. ACUTIPOLIUS</u>	.55 - .65	RED	MOTTLED
<u>P. LUNATUS</u>	.66 - .75	RED BROWN	STRIPED
<u>P. COCCINEUS</u>	.76 - .85	BLACK	FLECKED
		BROWN	FLECKS TENDING TOWARD STRIPES
ABCTESA - SEED WIDTH	COLLECTION NUMBER 26	YELLOW	
ORDINATE - SEED LENGTH		VIOLET	CHARRED
		SHORTER LINE INDICATES LIGHTER COLOR	

EXPLANATION OF SCATTER DIAGRAM COLLECTION NUMBERS, TABLE VII

Fig. 3, Mogollon

a, 215; b, 219; c, 224; d, 208; e, 209; f, 212; g, 210; h, 218; i, 214; j, 220; k, 222; l, 216; m, 211; n, 223; o, 221; p, 217; q, 213.

Fig. 4, Verde Valley, Arizona (Anasazi-Hohokam)

a, 205a; b, 195a; c, 195, 196; d, 195c; e, 195b; f, 185; g, 162; h, 201; i, 164; j, 185; k, 162d; l, 186; m, 204; n, 203; o, 138.

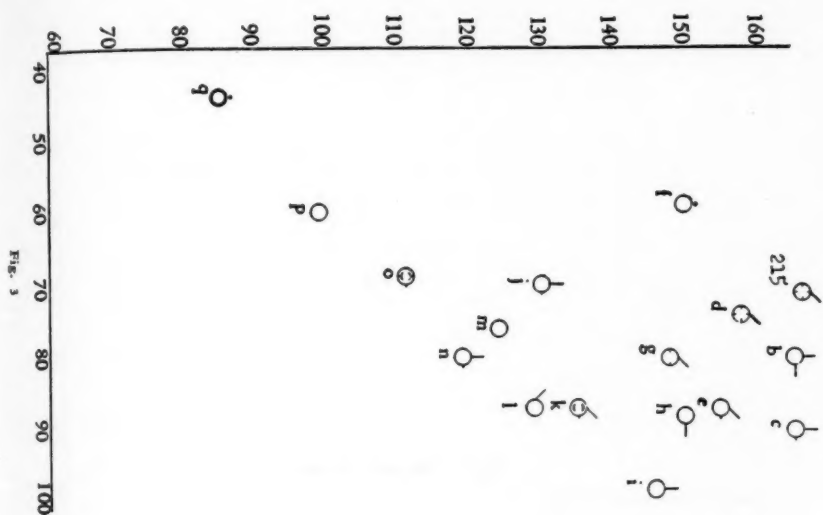


Fig. 3

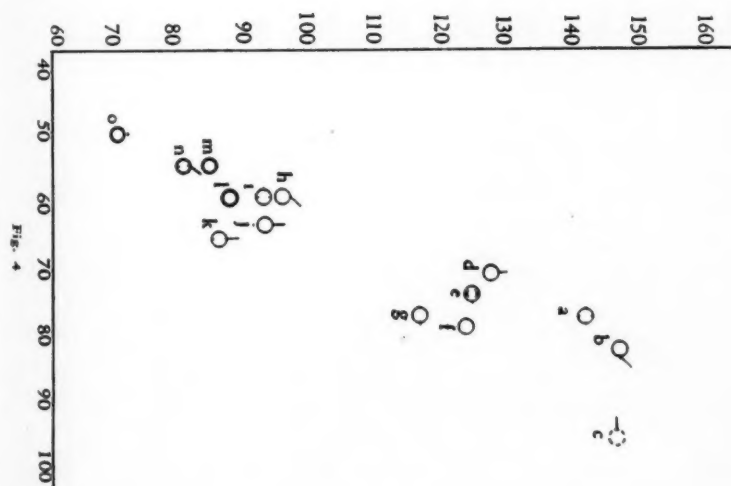


Fig. 4

Fig. 5. Northern Periphery

a—207; b—206a; c—206.

Fig. 6. Northern Arizona Anasazi

a—189; b—193; c—199, 194b; d—88, 161, 188, 190, 198; e—12, 160, 192; f—81, 202;
g—191.

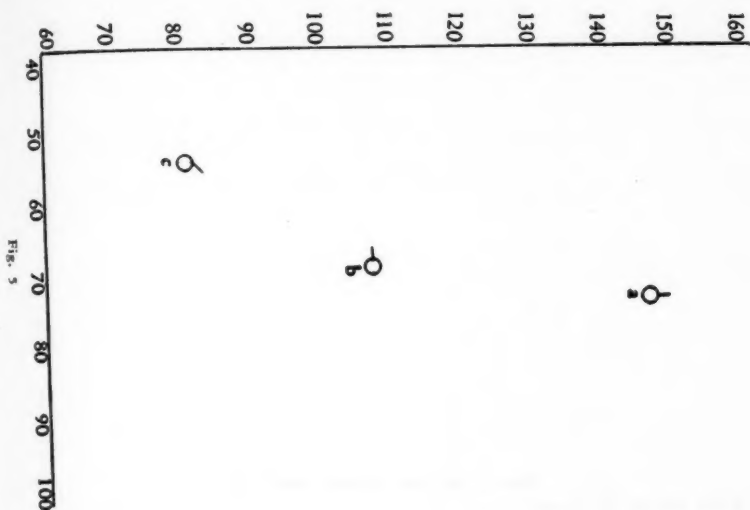


FIG. 5

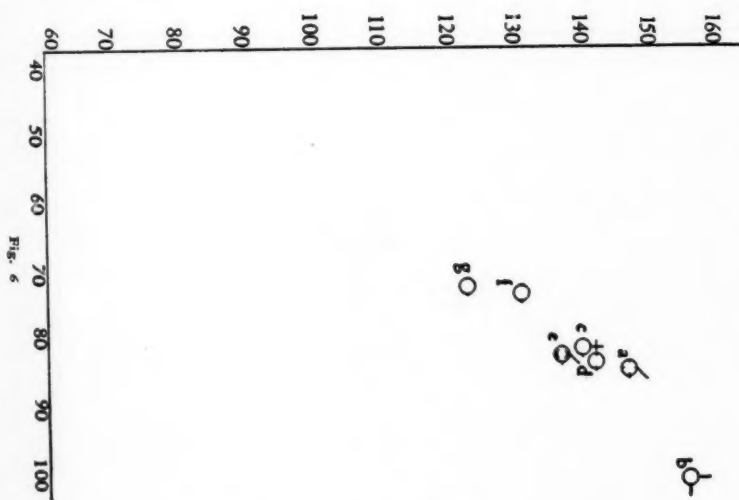


FIG. 6

Fig. 7. San Juan Anasazi, Mesa Verde

a—63, 65, 66, 67; b—64.

Fig. 8. Rio Grande Pueblos

a—9; b—106, 139; c—97a; d—103, 107, 157; e—105, 114, f—97b; g—98, 112; h—4;
i—109.

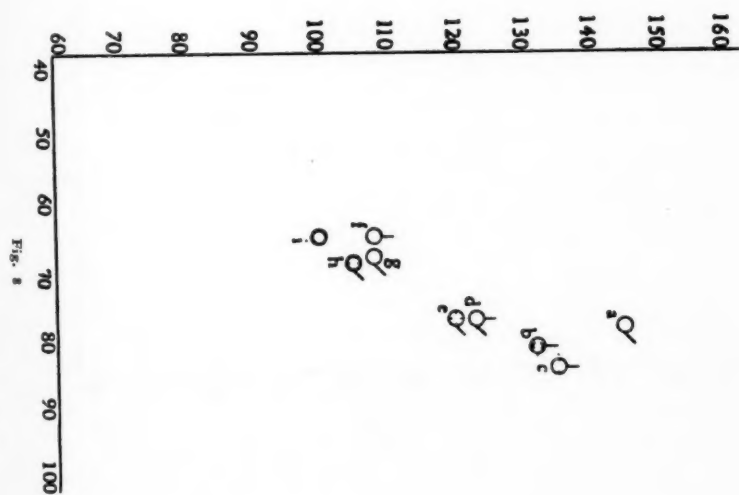
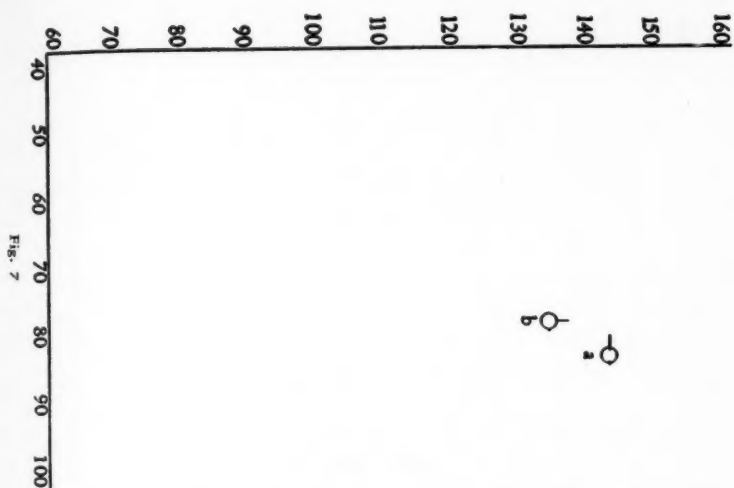


Fig. 9. Hopi

a—43b; b—17a; c—42; d—16, 24, 29; e—31a; f—35; g—35a; h—31, 32, 34; i—54; j—45, 46, 55; k—49c; l—17b; m—19; n—37; o—14, 56, 58, 59; p—50; q—26; r—27, 28; s—33; t—18, 43, 44; u—22; v—23; w—37, 38; x—36; y—40, 41; z—39.

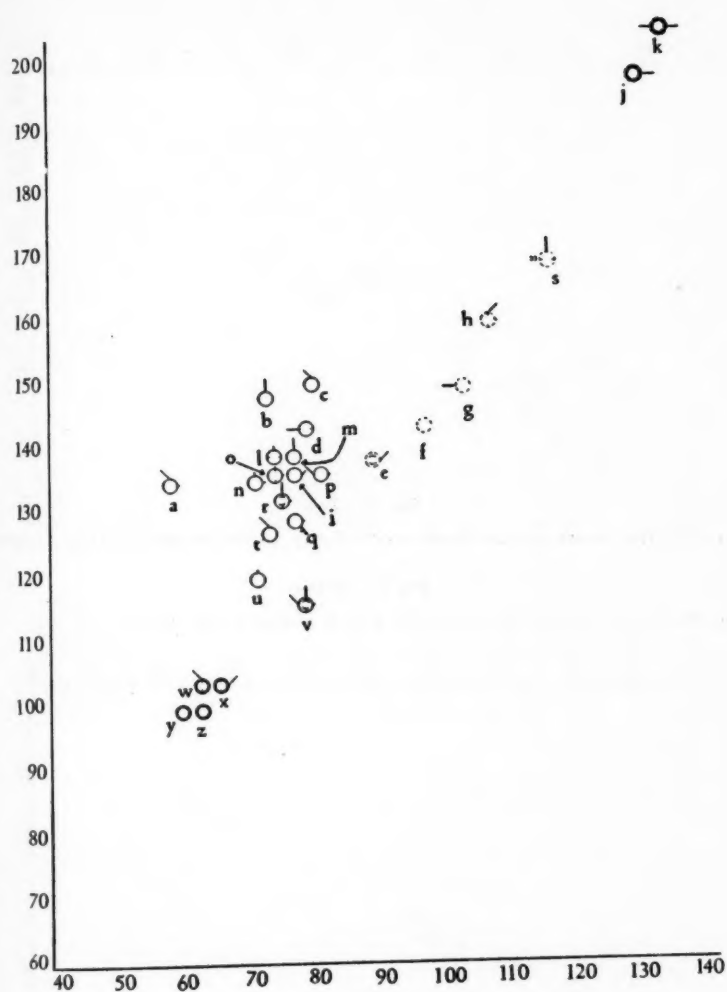


Fig. 9

Fig. 10. Zuni

a—153, 154; b—146; c—125; d—90; e—151; f—120; g—152; h—161; i—111; j—62; k—83.

Fig. 11. Navajo

a—86, 118; b—91, 104, 140; c—93, 123; d—119; e—124; f—128; g—85.

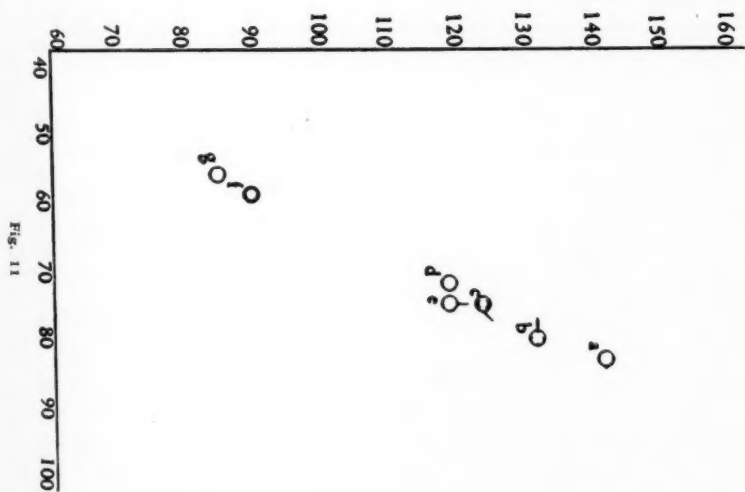
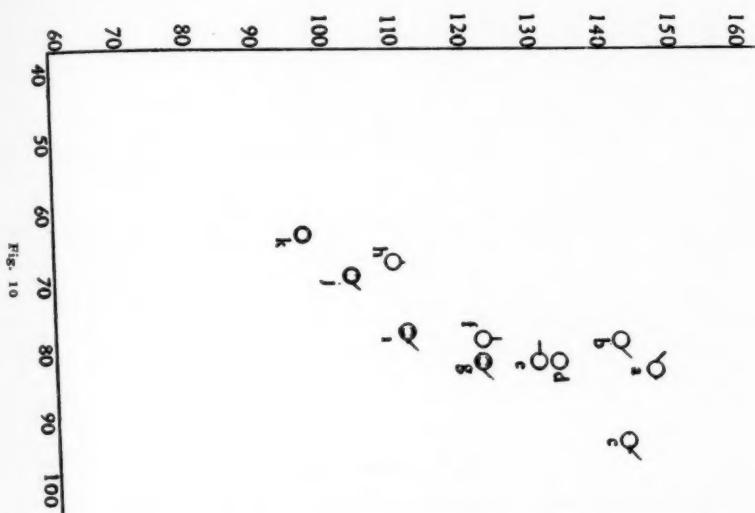




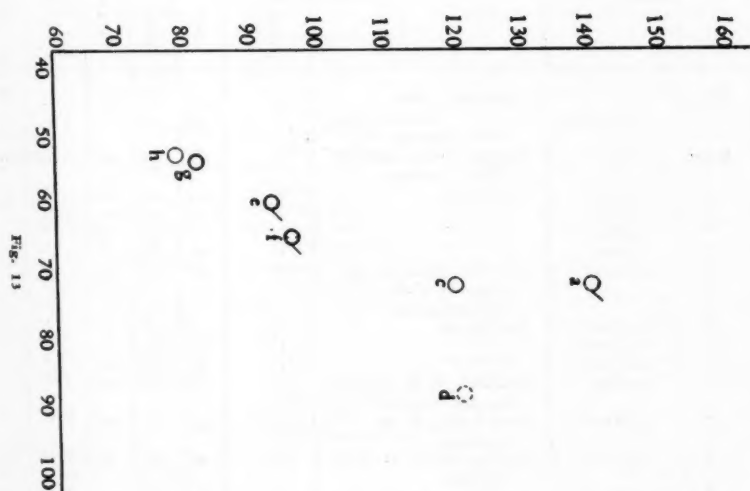
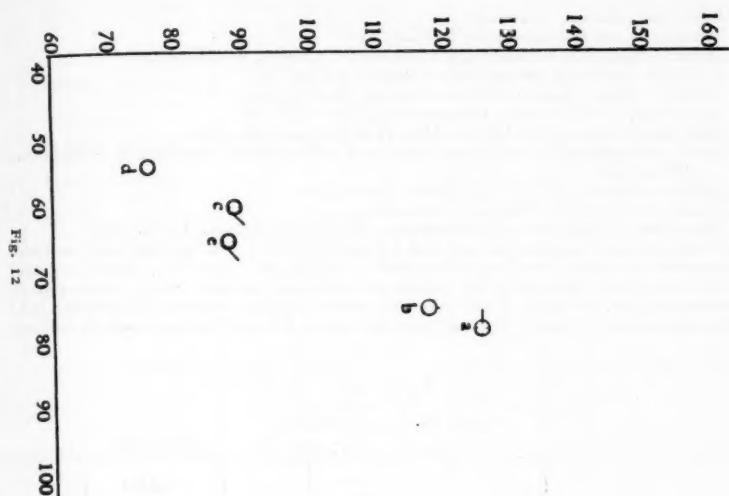
Fig. 12. Arizona Piman

a—142, 156; b—11, 94; c—11a, 87, 108, 137; d—10, 82, 116, 130; e—110.

Fig. 13. Colorado River Yunan

a—127; b—15a; c—126; d—149; e—143, 144, 145, 148, 150; f—134, 135, 136; g—5, 121, 122, 132, 133, 147, 158; h—117.





EXPLANATION OF TABLE VII

The following abbreviations are used:

Amerind — Amerind Foundation, Dragoon, Ariz.

Berke. — Museum of Anthropology, University of California, Berkeley, Calif.

C.N.H.M. — Chicago Natural History Museum, Chicago, Ill.

Denver — Denver Museum of Natural History, Denver, Colo.

Lab. of Anth. — Laboratory of Anthropology, Santa Fe, N. M.

Mesa Verde — Mesa Verde Museum, Mesa Verde National Park, Colo.

Mich. — Ethnobotanical Laboratory, Museum of Anthropology, University of Michigan, Ann Arbor, Mich.

M.N.A. — Museum of Northern Arizona, Tucson, Ariz.

Tucson — Arizona State Museum, Tucson, Ariz.

Univ. Ariz. — Department of Anthropology, University of Arizona, Tucson, Ariz.

Commonly accepted abbreviations are used for names of states. P. and B.M. refer to Pueblo and Basketmaker periods of the Pecos Archaeological classification under "Site, culture, and date."

Collection numbers followed by an asterisk are collections included in the scatter diagrams. The number of seeds measured, if less than the entire collection, is given in parenthesis under "Number and quantity of seeds." Pertinent notes on museum labels are included with the collection.

TABLE VII
LIST OF COLLECTIONS

Number	Collection source and number	Site, culture and date	Number or quantity of seed	Medial dimensions of seed (cm.)			Species or type
				Length	Width	Thickness	
3	M.N.A.	Havasupai. 1940	6	1.31	.78	.57	C 11
5	" 1047/4559	" Havasu Canyon, Ariz. Contemp.	3	.89	.58	.44	T 6
6a	Berke. 3-7867	Cocopa, Lower Colorado River. Contemp.	1	.78	.55	.43	<i>P. acutifolius</i>
6b	" 3-2976	Same as 6a	1	.94	.56	.40	"
6c	" 3-2982	" " "	1	.90	.61	.25	"
6d	" 3-2983	" " "	1	.82	.60	.38	"
6e	" 3-2984	" " "	1	.91	.61	.37	"
6f	" 1-62242	Cave near Jacumba, San Diego Co., Calif. Date unknown.	(1)	.82	.58	.35	"
6g	" 1-62241	Same as 6f	(1)	.88	.69	.37	"
6h	" 1-62240	" " "	(1)	.91	.61	.37	"
6i	" 1-62243	" " "	(1)	.80	.55	.40	"
7	" 2-17461	Sia Pueblo, N. M. Contemp. Escaped from cult.	(5)	.70	.53	.27	T 2
8	" 2-17537	Isleta Pueblo, N. M. Contemp.	2	1.06	.69	.43	T 4
9	" 2-17419	Acomita Pueblo, N. M. Contemp.	(5)	1.47	.78	.50	C 18
10*	" 2-17281	Pima, Santan, Ariz. Contemp.	(5)	.75	.52	.39	T 6
11*	" 2-17330	Papago, Ariz. Contemp.	(5)	1.22	.77	.55	C 28
11a*	" 2-17288	Pima. Ariz. Contemp.	(5)	.94	.64	.45	T 5

12*	Berke.	2-17765	Gourd Cave, Nitair, Tsegi Canyon, n. Ariz. P. III ?	3	1.44	.82	.64	C 14
13	"	2-17763	Same as 12	4	1.34	.74	.54	<i>P. vulgaris</i>
14*	M.N.A.	771/1744	Hopi Crop Surv. 1935	(10)	1.38	.83	.56	C 13
15a*	"	From Mus. display case	Havasupai. Contemp.	4	1.56	1.10	.62	L 4
16*	M.N.A.	771/1730	Hopi Crop Surv. 1935	(10)	1.42	.81	.61	C 11
17	"	771/1751	" " " "	(10)	1.14	.86	.68	C 25
17a*	Berke.	2-17694	Hopi	4	1.47	.76	.57	C 1
17b*	"	2-17577	"	5	1.38	.79	.48	C 26
18*	M.N.A.	1046/3935	" Contemp.	(10)	1.26	.76	.52	C 29
19*	"	771/1810B	Hopi Crop Surv.	(10)	1.38	.80	.60	C 3
20	"	725/2744	Hopi. Moencopi, Ariz. Contemp.	6	1.44	.66	.48	<i>P. vulgaris</i>
21	"	725/2745	Hopi Crop Surv. Moencopi, Ariz.	3	1.60	.82	.75	"
22*	"	771/1806	Hopi Crop Surv. 1935. "Similar to robust"	(10)	1.1	.74	.50	C 28
23*	"	771/1809a	Hopi Crop Surv. "Jacob's cattle"	(10)	1.16	.81	.65	C 14a
24*	"	756/745	Hopi Crop Surv. First Mesa, Ariz.	8	1.37	.80	.63	C 11
25	"	771/1741	Hopi Crop Surv. "string bean"	4	1.23	.77	.72	<i>P. vulgaris</i>
26*	"	771/1809B	Hopi Crop Surv. 1935 "Jacob's cattle"	9	1.32	.78	.56	C 14
27*	"	771/1771	Hopi Crop Surv.	5	1.22	.72	.55	C 2
28*	"	771/1823B	" " "	(5)	1.28	.80	.55	C 2
29*	"	1046/3939	Hopi, Hotevilla, Ariz.	(10)	1.48	.79	.59	C 11
30	"	771/1827	Hopi Crop Surv. "red string bean"	(10)	1.38	.74	.54	<i>F. vulgaris</i>
31*	"	771/1781	Hopi Crop Surv. "brown yellow lima"	(10)	1.60	1.08	.54	L 3
31a*	Berke.	2-17591	Hopi	3	1.37	.92	.44	L 5
32*	M.N.A.	756/B.729	Hopi Crop Surv.	(10)	1.58	1.08	.55	L 3
33*	"	771/1835	" " "	(10)	1.61	1.14	.52	L 4
34*	"	771/1768A	"red lima" Hopi Crop Surv.	10	1.57	1.02	.56	L 3
35*	"	771/1825	"brown lima" Hopi Crop Surv.	(10)	1.42	1.00	.53	L 2
35a	Berke.	2-17592	"white lima" Hopi Crop Surv.	4	1.47	1.03	.54	L 1
36*	M.N.A.	771/1727	Hopi Crop Surv. "mottled tepary"	(10)	1.03	.68	.39	T 4
37*	"	771/1808	Hopi Crop Surv. "black tepary"	(10)	1.01	.65	.38	T 7
38*	"	756/B727	Hopi Crop Surv.	(10)	1.04	.68	.39	T 7
39*	"	771/1807	" " "	(10)	1.02	.66	.48	T 3
40*	"	771/1758	" " "	(10)	1.00	.66	.42	T 3
41*	"	756/728	" " "	(10)	.99	.64	.42	T 3
42*	"	771/1742	" " "	(5)	1.49	.83	.47	C 29
43*	"	771/1838	"dark blue bean" Hopi Crop Surv.	(10)	1.22	.76	.54	C 29
43b*	Berke.	2-17635	"Hopi blue dye bean"	2	1.34	.61	.55	C 30
44*	M.N.A.	771/1769	Hopi Crop Surv.	(10)	1.30	.76	.50	C 29
45*	"	1046/3940	" " "	(5)	1.90	1.33	1.13	R 1
46*	"	906/E250A	" " "	4	1.87	1.18	.94	R 1
46a	"	771/1772	" " "	2	1.62	.80	.59	C 18
49a	"	725/B2740	" " "	3	1.97	1.21	.77	R 2
49b	"	854/2845	" " "	4	2.20	1.40	1.07	R 2
49c*	"	906/E250B	" " "	5	1.99	1.32	.98	R 2

TABLE VII (Continued)

Number	Collection source and number	Site, culture and date	Number or quantity of seed	Medial dimensions of seed (cm.)			Species or type
				Length	Width	Thickness	
50*	M.N.A. 771/1801A	Hopi Crop Surv. "yellow beans"	(10)	1.40	.82	.60	C 17
51	" 1046/3936	" " "	(10)	1.34	.74	.56	C 28
52	" 1046/4670	" " "	(10)	1.42	.82	.50	C 17
53	" 771/1809D	" " "	(10)	1.41	.82	.54	<i>P. vulgaris</i>
54*	" 771/1770	" " "	(10)	1.41	.80	.51	C 17
55*	" 906/E250A	" " "	3	2.05	1.28	1.14	R 1
56*	" 1046/3934	" " "	8	1.38	.78	.54	C 13
57*	" 771/B1730	" " "	13	1.38	.76	.56	C 11
		"purple string bean"					
58*	" 771/B1731	Hopi Crop Surv.	(15)	1.31	.71	.57	C 13
59*	" 771/1731	" " "	(15)	1.45	.82	.64	C 13
60	" 771/1837	" " "	(15)	1.45	.82	.58	C 17
61*	Berke. 2-17407	Zuni. Ojo Caliente, N. M. Contemp.	2	1.10	.69	.46	C 28
62*	" 2-17388	Zuni. N. M. Contemp.	(5)	1.04	.67	.38	T 4
63*	Mesa Verde 417/345	Cliff Palace, Mesa Verde. P. III	5	1.42	.74	.58	C 11
64*	" 3324/275	Cliff Canyon, Mesa Verde. P. III	2	1.35	.77	.63	C 1
64a	" 3441/298	Square Tower House, Mesa Verde. P. III	3	1.27	.76	.58	C 1
65*	" "	Same as 64a	5	1.45	.78	.63	C 11
66*	" 2848/171	Step House, Mesa Verde. P. III	10 (8)	1.37	.75	.57	C 11
67*	" 2488/86	Same as 66	½ pint (250)	1.42	.82	.59	C 11
68a	Amerind 992K	Kukendahl, s.e. Ariz. near Nogales. 1200-1450 A. D.	30 cc. 4 char. frag.	1.20	.64	—	<i>P. vulgaris</i> , subreniform subapiculate single cotyledons; testas destroyed by charring
68b	" "	Same as 68a	4 frag.	.89	.62	.43	<i>P. vulgaris</i> , possibly Cl2 20 or 27, testas affected by charring
69	" 1049	" " "	1 frag. charred	1.31	.72	—	Similar to 68a
70a	" P/501B(2)	S. Ariz. 16th cent.	2 charred	1.36	.97	.53	<i>P. lunatus</i>
70b	" "	" " " "	5 charred	.80	.50	.38	Probably a small-seeded <i>P. vulgaris</i>
70c	" "	" " " "	1 charred	1.55	.87	.55	<i>P. vulgaris</i> , entire, ends rounded

71	M.N.A.	N.A.862	Site unknown	Ca. 100 charred incl. frags. Nos. 71 -75 (6)	.94	.63	.58	Probably C 6
72	"	N.A.862	" "	(6)	1.20	.66	.47	Like C 19a, but smaller
73	"	"	" "	(10)	.91	.60	.46	Entire, rounded ends
74	"	"	" "	(5)	.67	.48	—	<i>P. vulgaris</i>
75	"	"	" "	(1)	.90	.61	—	Ends flat
76	"	508/NA1764B.2	Dead Man's Fort, Ariz. P. II	Ca. 50 frag., charred (9)	1.14	.62	—	<i>P. vulgaris</i> , round ends, some much curved, similar to 72
80	Berke.	2-17417	Acomita, N. M. Contemp.	5	1.23	.66	.11	C 1
81*	"	2-17764	Gourd Cave, Nitair, Tsegi Canyon, n. Ariz. P. III	4	1.31	.75	.59	C 2
82*	"	2-17291	Pima. Santan, Ariz. Contemp.	(5)	.84	.57	.44	T 6
83*	"	2-17384	Zuni, N. M. Contemp.	4	.97	.64	.42	T 3
84	"	2-17731	Cave, S. Francisco R., N. M. Undated	(5)	.86	.55	.42	T 6
85*	"	2-17347	Navajo, Jeddito, Ariz. Contemp.	(5)	.85	.56	.43	C 6
86*	"	"	Same as 85	4	1.42	.83	.58	C 9
87*	"	2-17290	Pima. Santan, Ariz. Contemp.	(4)	.91	.60	.42	T 5
88*	"	2-17766	Gourd Cave, Nitair, Tsegi Canyon, n. Ariz. P. III	(5)	1.30	.82	.64	C 11
89*	"	2-17720	Near Isleta, N. M. Contemp.	(5)	1.29	.76	.52	C 14
90*	"	2-17408	Zuni. Ojo Caliente, N. M. Contemp.	(5)	1.34	.82	.53	C 9
91*	"	2-17347	Navajo. Jeddito, Ariz. Contemp.	4	1.36	.82	.56	C 13
92	"	"	" " "	2	1.32	.77	.56	C 23
93*	"	"	Same as 92	2	1.26	.80	.57	C 14
94*	"	2-17316	Papago, Ariz. Contemp.	(5)	1.18	.75	.52	C 28
96	"	2-17480	Cochiti Pueblo, N. M. Contemp.	(5)	1.22	.78	.50	C 13 ?
97	"	"	Same as 96	(5)	1.10	.73	.43	C 9
97a*	"	2-17556	Picuris, N. M. Contemp.	4	1.35	.82	.47	C 26
97b*	"	2-17560	Taos, N. M. Contemp.	(5)	1.08	.65	.43	C 15
98*	"	2-17480	Cochiti Pueblo, N. M. Contemp.	(5)	1.10	.68	.45	C 23
99	"	2-17771 #1A	Turkey House, Casa Grande, Ariz. Hoho- kam-Anasazi	8	1.33	.80	.62	C 11
100	"	" #2	Same as 99	4	1.20	.82	.67	C 21
101	"	" #3	" " "	5	1.42	.81	.53	C 11
102	"	" #4	" " "	2	1.42	.78	.59	C 1
103*	"	2-17412	Acomita Pueblo, N. M. Contemp.	(5)	1.27	.77	.54	C 22
104*	"	2-17343	Navajo. Jeddito, Ariz. Contemp.	(5)	1.32	.80	.56	C 13
105*	"	2-17709	Truchas, N. M. Contemp.	(5)	1.21	.73	.51	C 13

TABLE VII (Continued)

Number	Collection source and number	Site, culture and date	Number or quantity of seed	Medial dimensions of seed (cm.)			Species or type
				Length	Width	Thickness	
106*	Berke. 2-17434	Acomita Pueblo, N. M. Contemp.	(5)	1.32	.81	.62	C 14
107*	" 2-17701	Chimayo, N. M. Contemp.	(5)	1.22	.78	.60	C 22
108*	" 2-17326	Papago, Ariz., near Mex. bord. Contemp.	(5)	.80	.55	.39	T 5
109*	" 2-17443	Laguna Pueblo, N. M. Contemp.	(5)	1.00	.65	.46	T 3
110*	" 2-17327	Papago. Big Fields, Ariz. Contemp.	(5)	.88	.65	.43	T 4
111*	" 2-17389	Zuni, N. M. Contemp.	(5)	1.12	.78	.64	C 14a
112*	" 2-17479	Cochi Pueblo, N. M. Contemp.	(5)	1.08	.69	.51	C 23
114*	" 2-17703	Cordola, N. M. Contemp.	(5)	1.28	.80	.60	C 13
115	" "	" " "	(5)	1.11	.72	.53	<i>P. vulgaris</i>
116*	" 2-17332	Papago, Ariz. Contemp.	(5)	.84	.54	.41	T 6
117*	" 2-17230	Yuma, Ariz. Contemp.	4	.78	.52	.42	C 27
117a	" 2-17728	" " " " " parched small white <i>P. vulgaris</i> eaten thus or ground"	frags. parched				T 6
118*	" 2-17344	Navajo, Jeddito, Ariz. Contemp.	(5)	1.34	.83	.57	C 9
119*	" 2-17341	Same as 118	(5)	1.20	.73	.50	C 2
120*	" 2-17390	Zuni, Ojo Caliente, N. M. Contemp.	(5)	1.27	.82	.50	C 3
121*	" 2-17262	Cocopa, Somerton, Ariz. Contemp.	(5)	.86	.60	.46	T 6
122*	" 2-17249	Mohave, Parker, Ariz. Contemp.	(5)	.84	.61	.47	T 6
123*	" 2-17345	Navajo, Jeddito, Ariz. Contemp.	(5)	1.24	.75	.51	C 14
124*	" 2-17778	Navajo, Two Gray Hills, N. M. Contemp.	(5)	1.16	.74	.53	C 22
125*	" 2-17387	Zuni, Ojo Caliente, N. M. Contemp.	(5)	1.44	.93	.73	C 24
126*	" 2-17272	Havasupai, Ariz. Contemp.	3	1.20	.68	.51	C 6
127*	" 2-17232	Yuma, Ariz. Contemp.	(5)	1.41	.72	.53	C 18
128	" 2-17346	Navajo, Jeddito, Ariz. Contemp.	(5)	.88	.60	.45	T 6
129	" 2-17259	Same as 128	(5)	1.34	.77	.58	<i>P. vulgaris</i>
130*	" 2-17310	Pima, Sacaton, Ariz. Contemp.	(5)	.76	.56	.41	T 6
131	" 2-17754	Kiet Siel, Tsegi Canyon, n. Ariz. P. III	4 charred	1.43	.97	.62	<i>P. vulgaris</i> (?) frags. of dark red testa
131a	" "	Same as 131	1 charred	.85	.45	.43	<i>P. acutifolius</i> ?
132*	" 2-17248	Mohave, Parker, Ariz. Contemp.	(10)	.89	.60	.46	T 6
133*	" 2-17235	Yuma Indians, Ariz. Contemp.	(10)	.86	.57	.41	T 6
134*	" 2-17261	Cocopa, Somerton, Ariz. Contemp.	(5)	.89	.62	.41	T 4

135*	Berke.	2-17261	Same as 134	(5)	1.03	.71	.42	T 4
136*	"	"	" " "	(5)	.96	.65	.38	T 4
137*	"	2-17337	Papago, Ariz. Contemp.	(10)	.89	.60	.38	T 5
138*	"	2-17756	Tusigoot, near Clarksdale, Ariz., Verde Valley. Hohokam, 1100-1400 A. D.	5 charred	.70	.45	.32	<i>P. acutifolius</i>
139*	"	2-17414	Acoma Pueblo, N. M. Contemp.	(5)	1.45	.90	.56	C 14
140*	"	2-17342	Navajo, Jeddito, Ariz. Contemp.	(5)	1.31	.83	.55	C 13
141	"	"	Same as 140	(5)	1.20	.81	.53	C 22 ?
142*	"	2-17318	Papago, Ariz., near Mex. bord. Contemp.	(5)	1.32	.80	.59	C 13
143*	"	2-17271	Havasupai, Ariz. Contemp.	(10)	.90	.60	.38	T 5
144*	"	2-17247	Mohave, Parker, Ariz. Contemp.	(5)	.97	.58	.35	T 5
145*	"	2-17250	Same as 144	(5)	.96	.60	.40	T 5
146*	"	2-17401	Zuni, Ojo Caliente, N. M. Contemp.	(5)	1.43	.76	.54	C 18
147*	"	2-17267	Walapai, Peach Springs, Ariz. Contemp.	(5)	.84	.58	.45	T 6
148*	"	"	Same as 147	(5)	.83	.59	.45	T 5
149	"	2-17233	Yuma Indians, Ariz. Contemp.	(5)	1.21	.87	.45	L 2
150*	"	2-17260	Cocopa, Somerton, Ariz. Contemp.	(5)	.93	.65	.41	T 5
151*	"	2-17405	Zuni, Ojo Caliente, N. M. Contemp.	(5)	1.32	.81	.60	C 11
152*	"	2-17409	Same as 152	(5)	1.23	.82	.54	C 14
153*	"	2-17406	" " "	(5)	1.52	.88	.56	C 17
154*	"	2-17410	" " "	(5)	1.48	.83	.57	C 17
155	"	2-17704	Cordola, N. M. Contemp. "bolitas"	(9)	1.10	.71	.55	C 22
156*	"	2-17324	Papago, Big Fields, Ariz. Contemp.	(5)	1.26	.78	.54	C 13
157*	"	2-17418	Acoma Pueblo, N. M. Contemp.	(5)	1.23	.71	.61	C 22
158*	"	2-17231	Yuma Indians, Ariz. Contemp.	(5)	.82	.56	.41	T 6
159	M.N.A.	695/NA2519 M96C	Kiet Siel, Tsegi Canyon, n. Ariz. P. III	1 charred	1.51	.85	.64	<i>P. vulgaris</i>
160*	"	621/405 M18	Wupatki Pueblo, Little Colo. R., 1000-1200 A. D.	1	1.14	.72	.61	C 14
161	"	712/NA2520.32	Turkey Cave, Tsegi Canyon n. Ariz. P. III	6 (3 immature)	1.42	.82	.61	C 1 or C 11
162*	"	692/A86b	Hidden House, Verde Valley, Ariz. 1100-1300 A. D.	1	1.16	.78	.60	C 11a
162a*	"	"	Same as 162	1	.84	.62	.48	C 12
164*	"	514/1814A. 231R6	Juniper Terrace, n.e. of Flagstaff, Ariz. 1000-1200 A. D.	4	.91	.58	.34	C 13
165	"	561/NA739.18	Walnut Canyon, Cliff Dwellings, Ariz. Sinagua, P. III	3	1.39	.82	.58	C 3 ?
166	"	583/117-U-26 #579	No information	2	2.67	1.66	1.09	<i>Canavalia ensiformis</i>
167a	Lab. Anth.	30/1343	Cave on S. Francisco R., undated	8 (5 parched)	.87	.63	.43	T 6
167b	"	"	Same as 167a	1 parched	.98	.60	.43	C 20 ?

TABLE VII (Continued)

Number	Collection source and number	Site, culture and date	Number or quantity of seed	Medial dimensions of seed (cm.)			Species or type
				Length	Width	Thickness	
168	365131. Vial 2	Sunny Glen Cave, Big Bend, Tex. Undated prehist.	12	1.38	.81	.61	C 9
169	" " 1	Same as 168	20 (10)	1.38	.80	.51	C 5
170	" " 1	" " "	1	1.07	.70	.58	C 14a
171	Tucson Rm. 70, Ariz. W. 10, 50	Pt. of Pines. Ca. 1280 A. D.	Ca. 1 qt. (15) charred	1.05	.64	.54	<i>P. vulgaris</i>
172	" " "	Same as 171	Ca. 30 & frag. charred (10)	1.50	.80	.60	"
173	" " "	" " "	3 charred	1.47	.72	.68	"
174	" G.P.11071	Gila Pueblo excavations	3	1.28	.74	.58	"
175	" "	Same as 174	4	1.33	.80	.63	"
176	" G.P.16962	" " "	2	1.20	.72	.57	"
177	" "	" " "	2	.87	.61	.48	C 12
177a	" "	" " "	1	1.37	.90	.56	<i>P. lunatus</i> , [L?]
178	" "	" " "	1	1.11	.78	.35	<i>P. vulgaris</i>
179	" G.P.11084	" " "	4	1.46	.78	.67	"
181	" G.P.11055	" " "	2	1.54	.82	.64	"
182	" "	" " "	1	1.14	.75	.47	"
183	" G.P.11032	" " "	2	1.51	.82	.68	"
184	" G.P.11046	" " "	1	1.48	.82	.61	"
185*	" G.P.19691	" " "	1	1.23	.80	.47	C 9
186*	" "	" " "	2	.88	.60	.45	T 6
187	" H.899 H.959 H.111 H.1115	Hodges #793, s.e. Ariz. Pre 1300. Hohokam	6 charred	1.70	1.10	.71	<i>Canavalia ensiformis</i> (Called "lima beans" by Carter, 1945)
188*	M.N.A. 695/NA2519 M223	Kiet Siel, Tsegi Canyon, n. Ariz. P. III, 1274-1286 A. D.	4 parched	1.38	.88	.62	C 11
189*	" "	Same as 188	(10) parched	1.47	.84	.57	C 19 or 19a
190*	" "	" " "	(11) parched	1.55	.81	.61	C 11
191*	" "	" " "	(15) parched	1.25	.71	.55	C 2
192*	" "	" " "	1 parched	1.35	.83	.55	C 14
193*	" "	" " "	5 parched	1.58	1.02	.54	C 8
194a	" "	" " "	16 parched	1.58	.85	.58	C 19a
194b*	" "	" " "	15 parched	1.40	.81	.57	C 1
195a*	" 692/A85	Murder House, Lay Canyon, Verde Valley, Ariz. P. III	2 parched	1.46	.84	.58	C 18

195b*	M.N.A. 692/A85	Same as 195a	1	1.24	.72	.55	C 14a
195c*	" "	" " "	1	1.27	.71	.57	C 1
195d*	" "	" " "	1	.95	.61	.39	C 20
196*	" "	" " "	2	1.45	.97	.48	L 1
197	" 712/NA2730.4	Dry cave, Tsegi-ot-sosi. B.M.I.	1	1.24	.67	.54	C 3 ?
			frag.				
198*	" 909/NA2520.13	Turkey Cave, Tsegi Canyon, Ariz. P. I-III	1	1.49	.78	.65	C 11
199*	" 712/NA2519M97	Kiet Siel, Tsegi Canyon. P. III	2	1.36	.76	.55	C 1
200	" " M97b	Same as 199	1 parched	1.48	.82	.55	<i>P. vulgaris</i>
			charred				
200a*	" " M97c	" " "	2	1.28	.72	.57	C 2
201	Tucson	Montezuma's Castle, Verde Valley, cent. Ariz., ca. 1300 A. D.	4	.94	.59	.42	C 20
202	"	Same as 201	1	.67	.52	.37	T 1
203*	"	" " "	1	.82	.55	.36	T 8
204*	"	" " "	3	.85	.54	.40	T 6
205*	"	" " "	8	1.47	.95	.55	L 1
205a*	"	" " "	1	1.41	.79	.61	C 11
206*	Univ. Ariz. B.P.6004 4590	Rock Shelter, Overton, Nev. P. II	ca. 100 (15 parched)	.81	.55	.39	C 12
206a*	Univ. Ariz. B.P.5990	Rock Shelter, Virgin R., Nev. P. II	1	1.09	.71	.44	C 11a
207*	Denver 7146	Fremont, s.e. Utah. B.M.	1	1.51	.75	.49	C 3
208*	C.N.H.M.	Hinkle Park, w. cent. N. M. Mogollon	3	1.58	.74	.51	C 19
209*	"	Same as 208	2	1.55	.87	.59	C 3
210*	"	" " "	2	1.48	.80	.56	C 5
211*	"	" " "	1	1.24	.76	.47	C 15
212*	"	Higgins Flat, near Reserve, N. M. After 1100 A. D.	6 frags. charred	1.50	.59	—	C 19
213*	"	Same as 212	60 (frags. charred) (4)	.85	.44	—	<i>P. acutifolius</i>
214*	"	Tularosa Cave, near Reserve, N. M. Mogollon. 300 B. C.—1100 A. D.	2	1.46	.98	.52	C 8
215*	"	Same as 214	2	1.66	.71	.54	C 19
216*	"	" " "	4	1.29	.87	.51	C 7
217*	"	" " "	4	.99	.60	.48	C 6
218*	"	" " "	1	1.50	.88	.60	C 9
219*	"	" " "	2	1.65	.80	.78	C 10
220*	"	" " "	1	1.30	.70	.58	C 1
221*	"	" " "	2	1.11	.69	.58	C 16
222*	"	" " "	19	1.35	.87	.59	C 5
223*	"	" " "	11	1.19	.80	.55	C 15
224*	"	" " "	1	1.65	.90	.59	C 3
225	Berke. 4-4821	Ica Valley, Peru. Early Nazca. 200 A. D.	20 lbs. (5)	2.47	1.37	.61	<i>P. lunatus</i> Yellow-tan to red-brown. Black-eyed, striped, spotted, or self
226	" 4-7255B	San Nicolas, near Supe, Peru. Middle Supe. 1100-1200 A. D.	150 total (5)	1.56	.85	.54	<i>P. vulgaris</i> Dark purple
227	" "	Same as 226	(5)	1.18	.92	.76	<i>P. vulgaris</i> Dark purple

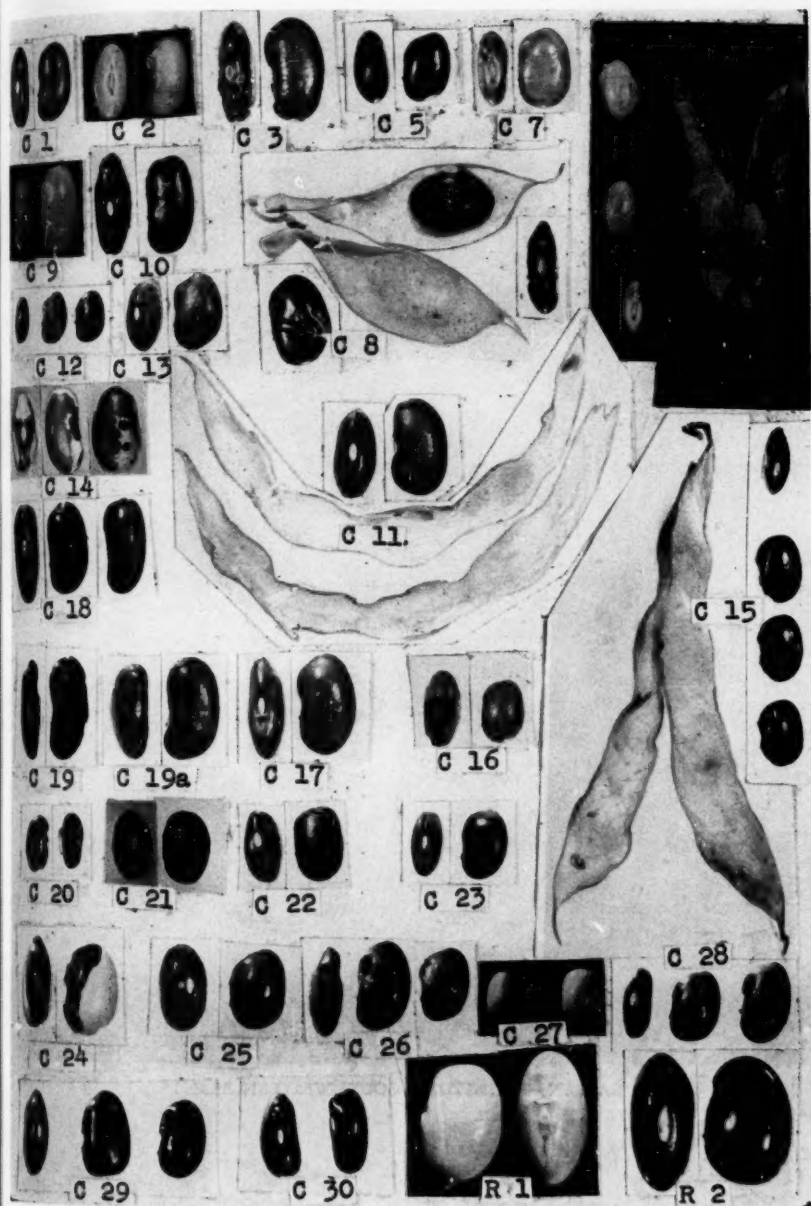
TABLE VII (Continued)

Number	Collection source and number	Site, culture and date	Number or quantity of seed	Medial dimensions of seed (cm.)			Species or type
				Length	Width	Thickness	
228	Berke. 4-7255B	" " "	(5)	1.50	.80	.62	<i>P. vulgaris</i> Red-brown with black eye extending ant. end
229	" "	" " "	(5)	1.51	.95	.64	<i>P. vulgaris</i> Red ground, ca. $\frac{3}{4}$ covered by solid black and ant. mottle
230	" "	" " "	Several hundred (5)	2.83	1.53	.75	<i>P. lunatus</i> Yellow-brown self, some with black ant. mottle
231	" 4-7269	" " "	1	1.80	1.26	.93	<i>P. lunatus</i> Black
232	Mich. 4445 c-3, c-4 4452 c-1, c-2 c-6	Zion Natl. Mon., s.e. Utah	(19)	1.25	.72	.56	C 11
233	" 4452c, c-5, 6	Same as 232	(14)	1.18	.77	.50	C 15
234	" 4445 b 4452 b	" " "	(12)	.88	.57	.38	C 12
235	" 4445 c-2, 4	" " "	5 (3)	1.39	.63	.63	C 19a
236	" 4452c, 5, 6	" " "	(2)	1.34 1.49	.70 .72	.60 —	C 1 ?

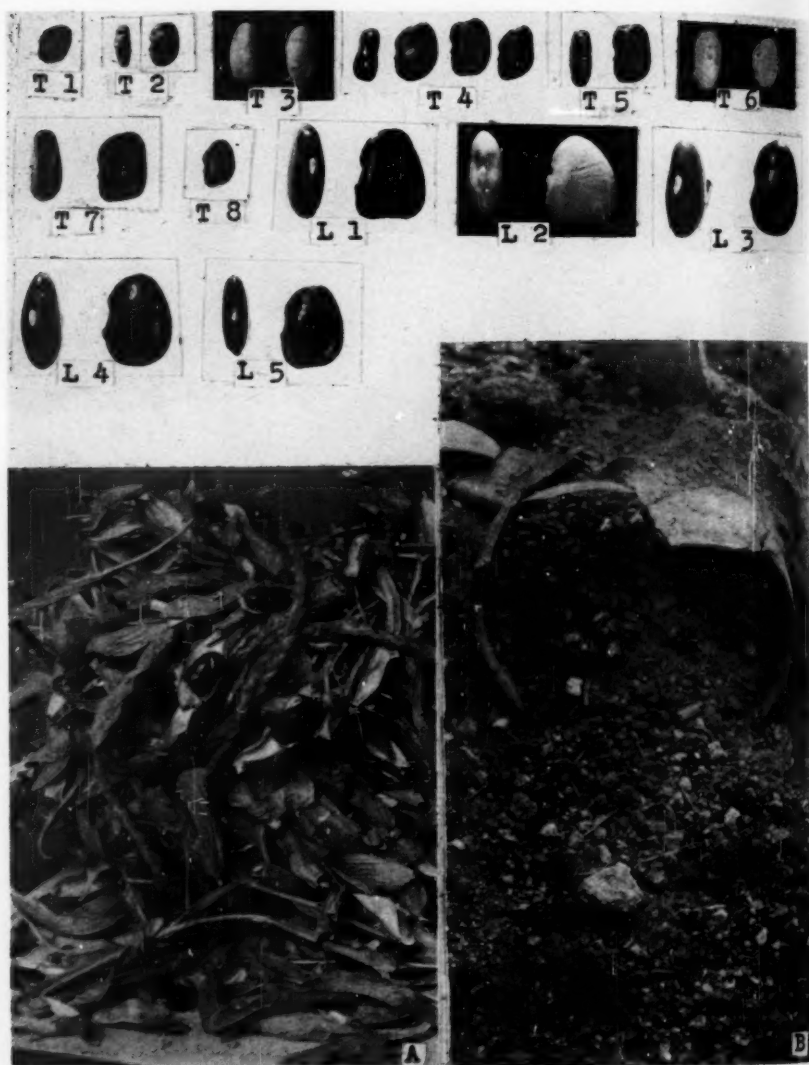
EXPLANATION OF PLATE

PLATE I

Common and runner bean types. Slightly less than natural size.



KAPLAN—PREHISTORIC SOUTHWESTERN BEANS



KAPLAN—PREHISTORIC SOUTHWESTERN BEANS

EXPLANATION OF PLATE

PLATE 2

T 1-T 8. Tepary types; L 1-L' 5. lima bean types. Seeds slightly less than natural size.

A. Dried pods and beans, type C11, Mesa Verde, Colorado. Pueblo III.

B. Charred beans, *in situ*. Point of Pines, Arizona.

[The following text is extremely faint and largely illegible due to the quality of the scan. It appears to be a list of items or a table of contents.]

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